PRACTICAL SAFETY METHODS AND DEVICES

MANUFACTURING AND ENGINEERING

BY

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PREFACE

Industrial accidents cost this country 35,000 human lives and more than $500,000,000 annually. In addition, dismemberments and other serious injuries total about 350,000 yearly, while the annual number of minor accidents, causing loss of time, exceeds 2,000,000. This statement does not include a very large number of cases of occupational diseases in which workers are either wholly or partially incapacitated, or which result in premature death. The annual loss in killed and wounded continues at a steady rate, and is now greater than the combined losses of the Union and Confederate armies during the Civil war.

The prevention of industrial accidents is a subject that is now receiving considerable attention in all sections of the country. Although safety methods have been systematically studied for a number of years in Germany, the fallacy has prevailed here that all work accidents were necessarily incident to industry, and that casualties were inevitable. A comparatively few employers and safety engineers, and the accident indemnity companies, have clearly demonstrated that this assumption is incorrect; furthermore, that it is possible, practicable, profitable, and eminently humane to prevent a very large proportion of industrial accidents.

This book is intended to provide for employers, superintendents, foremen, underwriters, safety inspectors and engineers generally, a convenient summary of standard safety methods and devices as developed and perfected by those who have specialized in this subject. Tried and proven methods and devices are described and exemplified. The book is a result of careful observations made in hundreds of mills and manufacturing establishments, in building and construction work, railroad operation, handling explosives, and mining. It reflects the experience, methods and ideas of practical men,—manufacturers, operators, contractors, and engineers who are prominent in varied fields of industrial activity. No attempt has been made to cover the subject in all its branches. An exhaustive treatment, within the limits of a book of this kind, is altogether impossible.

It is believed, however, that general principles are so suggested as to be useful in special and exceptional applications not specifically described in the following pages.

We should recognize that safety methods and devices are in a continuous state of development. What to-day may be considered good practice or an adequate safeguard, may to-morrow be superseded by a radical improvement. Standardization of safety methods and devices is in its infancy. Each succeeding year will witness important changes. The underlying principles, however, are now fairly well defined.

Acknowledgment is due to many individuals and organizations whose co-operation has been generously provided. Free reference has been made to the bulletins of the United States Bureau of Mines. The chapter on Explosives is adapted from the "Manual of Explosives" of Professor Courtenay DeKalb, published by the Ontario (Canada) Bureau of Mines. The safety bulletins and rule books of the United States Steel Corporation have afforded much valuable material. The subject matter of the chapter on Grinding Machinery has been derived largely from the experience of the Norton Company. The bulletins of the National Founders' Association have aided in preparing the chapter on Iron and Steel. The Utica Mutual Compensation Insurance Corporation has contributed a number of photographs, and has accorded permission to reprint the safety rules contained in one of its bulletins.

GEORGE ALVIN COWEE

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PRACTICAL SAFETY METHODS AND DEVICES

CHAPTER I

INTRODUCTORY

THE progress of the "Safety First" movement that is now sweeping over the United States has been remarkably rapid. The "Safety First" slogan has caught the attention and interest of the entire country. It is seen and heard on all sides; its appeal is world wide. Humanity demands safety!

Workmen's compensation laws have been enacted in twenty-nine states within the past few years, and the enactment of similar laws in all other states is certain to follow very shortly. These laws compel employers to insure their employees against accidental injuries sustained during hours of employment. This places a serious economic problem before the people of this country. The prevention of accidents has become of vast importance to employers and employees, and to the public at large, from both the financial and humane points of view.

Safety engineering has become a well established profession. It is, however, a comparatively new field of endeavor. Nevertheless, its importance is indicated by the millions of dollars that are annually being spent by employers of labor in safeguarding their machinery and workplaces, and in educating their employees; also, by the yearly waste of at least $500,000,000 which is now incurred by preventable accidents. To this monetary factor should be added an untold amount of human suffering and sorrow, the maimed and incapacitated beings which each

year's accidents bring forth, and, finally, the death roll of industry.

It is a generally conceded fact that safety is essential to efficiency. No company that has many work accidents is now considered highly efficient. Accidents cause disorganization and delays. They have a destructive effect on the morale of any working force. Danger breeds contempt; whereas, safety promotes co-operation and efficiency. Employers are spending a great amount of time and money in teaching safety and efficiency to their employees with the full realization that the one is practically useless without the other, that they are interdependent, and that both are necessary for economy. Thus safety and efficiency go hand in hand.

Education is the keynote to universal safety. The time is not far distant when courses in safety engineering will be embodied in the curriculum of every technical school and college. Safety is already being taught in some of our public schools. If we are to successfully prevent accidents, we must begin by teaching and training our school children and students in safety work. The children and students of to-day are the workers and employers of tomorrow. The public school is the logical starting point for this educational campaign, and the work should be extended to, and amplified in, our technical schools and colleges.

Approximately thirty percent of industrial accidents are preventable by means of safeguards, if properly used and maintained in good condition. On the other hand, at least sixty percent of these accidents can be eliminated by the proper education of employees in matters pertaining to safety; in other words, teaching employees to be cautious and thoughtful at all times, instructing them to think of their own safety and that of their fellow-workmen, and training them to refrain from taking unnecessary risks. At least ninety percent of all work accidents are actually preventable. Therefore, if the above methods are used to

check this gigantic waste, employers of labor may expect to ultimately save the entire cost of insurance on these preventable accidents. Employees may also expect to save at least seventy-five percent of the losses in wages now incurred by these casualties.

Accident prevention is unquestionably a paying investment. The most striking proof of this statement is revealed in the experience of the United States Steel Corporation. Approximately $5,000,000 was expended during the last eight years by the subsidiary companies of the Corporation for the installation of safety devices and the adoption of accident prevention measures. In three years the safety work resulted in the prevention of 6,308 accidents which would have otherwise occurred if the accident ratio of preceding years had been maintained. In other words, the accident rate has been reduced approximately forty percent (40%) during the past five years. Likewise, the saving in casualty expense over expenditures for safety, during the past three years, has been over thirty-five percent (35%). When we consider, in connection with this exhibit, that the compensation to injured workmen during this period was materially increased, the emphatic conclusion is that safety pays.

CHAPTER II

ORGANIZATION OF SAFETY COMMITTEES

As THE education of employees is the most important factor in the elimination of preventable accidents, this should receive first consideration. Education can be most effectively brought about through the organization of safety committees by each company. Manufacturing corporations, railroad companies, and mining companies from all sections of the country have testified that efficient safety organizations have, on an average, reduced the number of their accidents by at least fifty percent. Some companies have even reduced the number of their accidents by as much as seventy percent. A very large number of representative companies in this country now maintain their own safety committees. Such an organization is not only of great service in the prevention of accidents, but it increases the efficiency of the workers, and promotes universal good will.

In order to make the safety organization a success, it is first necessary to convince employees of the sincerity of the safety work; also, that the prevention of accidents is for the benefit of all employees as well as for the company. Employees should be made to clearly understand that sustaining serious accidents, which may dismember them, will greatly reduce their future earning power. They should also be made to realize that it costs the company a considerable sum of money to educate them to efficiently perform the work for which they are engaged. Their attention should be called to the untold misery and suffering which would befall their families, in case they are seriously injured or killed. It is absolutely essential to

secure the hearty co-operation of employees in the safety work.

Many of the large companies interest their employees through motion pictures, and illustrated talks and lectures. Motion pictures, however, can not always be readily obtained for use in educating employees of smaller companies. Nevertheless, illustrated talks and lectures on accident prevention are feasible, and extremely useful. Also, an average size company can print, or have printed, monthly bulletins or pamphlets containing several photographs or drawings of dangerous machinery, safeguards, unsafe places and dangerous practices, and methods of correcting them. The bulletin should also contain interesting safety literature and statistics. These can be advantageously intermingled with humorous stories, jokes, and comic drawings, which tend to attract and hold the interest of the employees. This variety gives greater assurance that the whole bulletin will be read by each employee. All safety suggestions which are adopted, together with the name of employee making the recommendation, should also be printed in the bulletin. Many companies

Fig. 1
Safety bulletin board.
Courtesy Middletown Car Company.

have their own books of safety rules which are distributed to all workers. Rule books, warning signs, some of the safety literature, and notices should be printed in as many languages as are spoken by employees.

Bulletin boards are also valuable. (Fig. 1.) These should be located at the entrances to the factory, or in each department. Every week, safety literature, photographs, and drawings, as above described, should be posted upon these bulletin boards; also, any new rules or regulations which the company may adopt.

"Safety First" slogans may be printed upon the back of pay envelopes — a new slogan for each week. Many of the ideas conveyed by these maxims will permanently fix themselves in the minds of employees.

FIG. 2
Safety suggestion box near factory entrance.
Courtesy Commonwealth Steel Company.

Suggestion boxes, in which employees may slip memoranda containing their ideas in writing regarding the improvement of conditions and efficiency, should be maintained at entrances to the factory. (Fig. 2.) Workmen should be urgently requested to make recommendations. From such a source, many valuable suggestions are received. Suitable forms should be employed to systematize the work. The Eastman Kodak Company uses the following forms in this connection, which are self-explanatory:

EASTMAN KODAK COMPANY

Suggestion Blank

This Company welcomes suggestions from employees which will tend to make working conditions safer, reduce the cost of production, improve the appearance of the goods, improve the methods of manufacture, and increase the efficiency and general condition of the plant.

[*Take care to clearly define, describe and explain all suggestions. When suggestion is applicable to a machine, give the machine number and exact location.*]

Remember that all suggestions adopted are of value, and that they will be treated according to their merit.

____________________ General Superintendent Date ____________________

I respectfully submit the following suggestion: __________________________

____

____

____

____

____

Signature of Employee

Name ____________________ Number __________

Dept. ____________________________

EASTMAN KODAK COMPANY

Suggestion Acknowledgement

Mr. __________________________ Date ______________________

We desire to thank you for your suggestion regarding

____

____

____

This has been referred to the Suggestion Committee for action, and will be known as No. __________.

You will be advised of final action at a later date.

__________________________________ *Manager.*

EASTMAN KODAK COMPANY

SUGGESTION REPORT

Mr.____________________ Date____________________

Your suggestion No.________ relative to

____

____

____

has been finally approved, and an award of $._________ has been placed to your credit, which you can secure by calling at the Cashier's office. We wish to thank you for this suggestion. If it is not in operation within a reasonable time, you are requested to notify some member of the Suggestion Committee.

____________________________*Manager.*

EASTMAN KODAK COMPANY

SUGGESTION ACKNOWLEDGEMENT

Mr.____________________ Date____________________

Regarding your Suggestion No. __________ relative to

____

It has not been approved for the following reasons:

____

____

____________________________*Manager.*

Some suitable distinction or award is necessary to create a spirit of interest and enthusiasm among employees, and to stimulate suggestions. Many companies offer cash prizes to employees making the most valuable suggestions. These awards are made each month. Some companies offer at least one dollar for every unsafe place or dangerous practice which is brought to the attention of their safety departments. Other companies offer novelties, such as watch fobs, cigar cutters, pipes, stick pins,

books and other useful articles. Some companies offer a gold "Safety First" button, which may be worn in the lapel of the coat. As soon as an employee learns all of the rules adopted by the company, having passed an oral examination by his foreman, he is awarded one of these buttons. His name is then added to the list of "Safety First" men in the employ of the company.

Workmen's safety committees are especially important. These should consist of several workmen in each department. Monthly meetings should be held for the discussion of accident prevention. The personnel of these committees should be changed every three months. Where workmen gather in a meeting of their own, to the exclusion of their superiors, they feel much more at ease. They then frankly express their own ideas, whereas, if the meeting were in charge of the superintendent or a foreman, they would be loath to advance their opinions upon any subject. The workmen should be allowed to appoint their own safety inspector, who should serve for a period of one month. Each week, this inspector should be given some printed form of a report to fill out and hand in to the safety department. He should report every unsafe place or unguarded machine, and also caution workmen against any unsafe practices he may observe. Some companies maintain a box of red tags in each room. As soon as any dangerous unguarded part of a machine or an unsafe place is discovered, a red tag is attached thereto. Every employee in the factory should have the privilege of attaching these tags. They should not be removed until the unsafe condition has been eliminated.

Foremen can do much toward securing the interest and support of employees. They can do more than anyone else in the company to make the safety organization a success. If a workman believes that his foreman is sincere in his desire to prevent accidents, to promulgate the proper use of safeguards and safety appliances, and to eliminate unsafe practices, he will usually attempt to carry

out his foreman's wishes. It is necessary to secure the co-operation of every foreman. Those who are not willing to carry on the work of accident prevention in an enthusiastic manner should not be retained in the employ of any company. No intelligent foreman will dispute the desirability of preventing accidents.

Each company should clearly impress upon the mind of every workman that those who take an active interest in the prevention of accidents, make recommendations for eliminating unsafe conditions and dangerous practices, and that those who abstain from liquor, shall be considered, in preference to others, for promotion and advancement. With a view toward encouraging workmen to report dangerous practices, the company should assure all employees that nobody, who is reported for the first time, will be disciplined. A workman who continually indulges in dangerous practices is a menace to the safety and welfare of his fellow-workmen. Such men should be discharged.

One of the most important methods of interesting workmen is through the medium of an accident prevention score-board. The Dodge Manufacturing Company has used a score-board of this kind with great success. The method of operation, and experience in the use of their score-board, is given in the following article by W. L. Chandler, Supervisor of Insurance of the Dodge Manufacturing Company:

"The widespread publicity and enthusiasm that have been attached to the Dodge Accident Prevention Score-Board well justifies an official statement of its worth and success in the minimization of accidents in the plants of the Dodge Manufacturing Company. Since its introduction in 1912, thousands of letters have been addressed to the company asking for more definite particulars regarding its operation than could be gathered from the various channels through which its use has been made public.

"In the first place, the score-board was designed and built as sort of a 'family affair' among the Dodge workers;

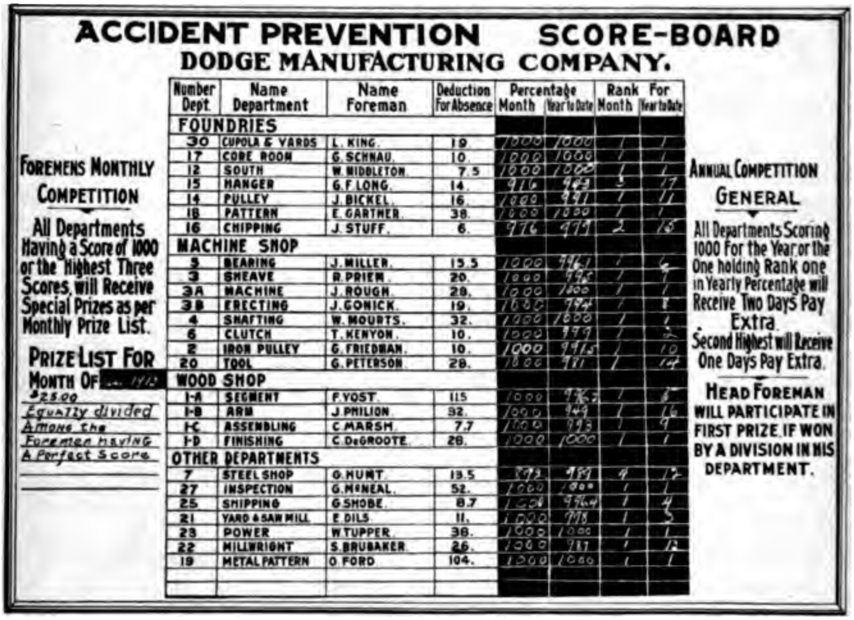
its operation was simple; but its scope among our work-a-day lives was almost as far reaching as the daily task itself. Men and employer regard it alike; with the same friendly spirit of competition that would surround a winter tournament of checkers. Little thought was given to the great welfare work it was destined to do; and practically no one regarded it from the humane standpoint; that is, not at first.

"But just as the spirit of enthusiasm carries a National or American League ball team on its world pennant race; just as the ambitious salesman throws every effort into a sales competition; just so that same spirit has invaded the lives of our workers until, from a friendly report board, it has become a hard fought field of contest between, first, whole departments, and second, between the individuals of different departments. To see 1,000 scored for a division is a personal achievement to every man in that division; and woe betide the individual member of these work-platoons who, through carelessness or thoughtlessness is the cause of penalty to his associates. To-day the Dodge score-board is as much a pride to the establishment as a record-breaking pulley or transmission equipment; one representing achievement in human conservation and efficiency, just as the other marks a mile-stone in mechanical progress.

"The Dodge Accident Prevention Score-Board stands just inside the main gate of the factory. It is 24 feet long, and on it are shown the departments, foremen, percentages for month and year, and rank of the various competing divisions. A reproduction of this board is here shown. (Fig. 3.)

"The starting point is 1,000 both for year and for month. Each division is penalized according to its accidents — minor accidents of less than one day's absence not as yet being considered. Each day's absence bears a percentage charge in proportion to the total number of 'men-days' per month per division.

"There are 26 divisions in the Dodge competition of various degrees of natural hazard and of wide variation in numbers of men. The degree of hazard is disregarded in our business which covers the same general subject throughout the plant; the differentiation being considered as equalized in the choice or selection of men with reference to



Number Dept.	Name Department	Name Foreman	Deduction For Absence	Percentage Month	Percentage Year to Date	Rank For Month	Rank For Year to Date
FOUNDRIES							
30	CUPOLA & YARDS	L. KING.	19.	1000	1000	1	1
17	CORE ROOM	G. SCHNAU.	10.	1000	1000	1	1
12	SOUTH	W. MIDDLETON.	7.5	1000	1000	1	1
15	HANGER	G. F. LONG.	14.	916	989	5	17
14	PULLEY	J. BICKEL.	16.	1000	991	1	11
18	PATTERN	E. GARTNER.	38.	1000	1000	1	1
16	CHIPPING	J. STUFF.	6.	976	999	2	16
MACHINE SHOP							
5	BEARING	J. MILLER.	15.5	1000	996.1	1	6
3	SHEAVE	R. PRIEM.	20.	1000	995	1	7
3A	MACHINE	J. ROUGH.	28.	1000	1000	1	1
3B	ERECTING	J. GONICK.	19.	1000	994	1	8
4	SHAFTING	W. MOURTS.	32.	1000	1000	1	1
6	CLUTCH	T. KENYON.	10.	1000	999	1	2
2	IRON PULLEY	G. FRIEDMAN.	10.	1000	991.5	1	10
20	TOOL	G. PETERSON.	28.	1000	981	1	14
WOOD SHOP							
1-A	SEGMENT	F. YOST.	115	1000	996.5	1	5
1-B	ARM	J. PHILION.	32.	1000	949	1	16
1-C	ASSEMBLING	C. MARSH.	7.7	1000	993	1	9
1-D	FINISHING	C. DeGROOTE.	28.	1000	1000	1	1
OTHER DEPARTMENTS							
7	STEEL SHOP	G. HUNT.	13.5	993	989	4	12
27	INSPECTION	G. McNEAL.	52.	1000	1000	1	1
25	SHIPPING	G. SHOBE.	8.7	1000	996.4	1	4
21	YARD & SAW MILL	E. DILS.	11.	1000	998	1	5
23	POWER	W. TUPPER.	38.	1000	1000	1	1
22	MILLWRIGHT	S. BRUBAKER.	26.	1000	987	1	12
19	METAL PATTERN	O. FORD.	104.	1000	1000	1	1

Fig. 3
Accident prevention score-board.
Courtesy Dodge Manufacturing Company.

their ability and fitness for their respective class of work. As to the variation in the sizes and groups of workers, we meet this by establishing a differential charge per man per day for time off, which is computed by reducing each division to men-days for each month, and using a multiplier of 10 to raise the figures to a more workable and understandable basis.

"A division working 50 men for 25 days per month amounts to 1,250 men-days; divide 1,000 by 1,250 and

multiply the result by 10 equals 8 points for each man off one day on account of accident in that division. Wide variations noticed in a year's competition in the different divisions should be the basis of an adjustment of this penalty charge, which adjustment should not have to be made during a month.

"In this manner, large and small divisions are equal as to their penalties. In the fourth column of the scoreboard will be noticed the figures which represent the deductions for absence in that division.

"We disregard small accidents that do not entail appreciable loss of time, and we do not penalize for the remainder of the day on which the accident occurs. It is possible by this provision to insure the prompt report of all accidents, however small, so that we may be sure of proper attendance, and avoid, as far as possible, such suffering as may be otherwise charged to secrecy on the part of either men or division superintendents.

"At the end of 12 months, the employees of the divisions scoring 1,000 receive two days' extra pay, or such part of that amount as their time and employment bear to the full year. If none scores 1,000, then the highest ranking department receives two days' extra pay, and the second highest, one day extra pay. General foremen of any division under them earning these premiums also participate on the same basis, but may earn but one prize if other divisions under them score perfect.

"The original plan was to distribute $25 in cash each month to all foremen of divisions earning perfect scores, but due to the relative importance, and the efforts of the foremen with a widely varying number of men to deal with, we were obliged, in fairness, to change this arrangement so that one-half of each prize is paid on a flat basis, and one-half distributed according to the number of men overseen. Thus a foreman in charge of 50 men will get a proportionately larger premium than one in charge of 10 men. It may be noticed that the cash prize is rather

small, and to some might be even considered trivial; but to such there has not come the meaning of the spirit back of the Dodge Accident Prevention Board as it prevails in our factory. It is the difference between success and loss that counts, and men who work at the lathe, the forge, or the cupola, have the same aspirations to participate in the winning spirit that inspires any team or organization, however or whenever formed. Several efforts have been made by psychologists, visiting our plant, to analyze the mental attitude which these men must carry, and it has been the unanimous opinion that departmental loyalty is the first stone, the great foundation, upon which stand the success and co-operation of this idea. It is the aim of each division to head the list, and men must feel that they have a chance of winning throughout the year. This interest is fostered by making up the yearly basis out of the monthly average. The great thought is then concentrated on the yearly contest, and the discouragement of any unfavorable monthly showing is avoided because any other division may have a sufficient penalty in some months throughout the year to equalize these unfavorable periodical conditions.

"We have found that this system is a matter of personal interest to both foremen and employees, and so intense has the competition become, at times, that an unforeseen condition arises which must be met by extreme diplomacy, and that is the ill-feeling that may be occasioned against a worker who has been responsible for causes which might have been controlled. Careful investigation and study have shown that the personal interest manifests itself, and the feeling that the loss must be minimized is responsible, to a great extent, toward urging men to get back to work as quickly as possible. The foremen of the various divisions of the factory are members of a safety committee which meets at regular intervals under the direction of the General Superintendent. A board of governors of five looks after the details of inspections, reports, inves-

tigates complaints, and approves the monthly penalty charges. This has served as an admirable promotion toward the further education of foremen in matters pertaining to accident prevention, as well as sanitation, cleanliness, and fire prevention, etc.

"For the year closing September, 1913, 10 divisions out of 26 showed perfect scores. The division ranking 16, the lowest, has a penalty of but 51 points. Included in the perfect scores is the South Foundry, the division in which our heaviest work is produced, making single castings up to 50 tons in weight and generally classed as a hazardous occupation. An analysis of the year ending September, 1913, shows 161 accidents — 17 applying on foot, 77 on eye, 45 on hands or fingers, 45 on scalps or face, 6 on burns or scalds, 5 miscellaneous. The total expense of first aid was $308.50; hospital service, $31.50; claims, $50; a total of $390. Time lost was figured at 218 hours, thus the average cost per accident was $2.42.

"For the 12 months ending September, 1914, 11 departments of the 26 showed an improvement over their record for year ending 1913. Nine departments of the 26 showed a decline. Six departments maintained their averages of the previous year, and five of these six have now presented perfect scores on 1,000 for two years. With one exception, all hazardous departments show a gain."

OUTLINE OF SAFETY COMMITTEES

A Central Safety Committee should consist of the following: General Superintendent (Chairman), a Safety Inspector (Secretary), and three or more department superintendents, foremen or workmen. This committee should hold monthly meetings to discuss safety conditions and efficiency in the plant, and consider all suggestions and recommendations received during the month. Records should be kept, in a book provided for the purpose, of the minutes of all meetings, and of all suggestions and recommendations received.

The duties of the Central Safety Committee should be:

1. To have charge and supervision over all safety work.
2. To establish standards for safeguards.
3. To formulate rules and regulations.
4. To carry on an educational campaign among employees.
5. To maintain suggestion boxes, into which employees are urged to slip recommendations or ideas in writing, which will improve the safety conditions and efficiency in and about the plant.
6. To maintain bulletin boards upon which safety literature, illustrations, instructions and rules should be posted.
7. To provide and maintain ample "First Aid" equipment.

The duties of the Safety Inspector should be:

1. To inspect for need of safeguards.
2. To see that safeguards are maintained in good condition.
3. To see that safety devices are used.
4. To inspect for congested and unsafe conditions.
5. To inspect for unsafe practices.
6. To inspect for unsanitary conditions.
7. To inspect all fire apparatus.
8. To act as secretary, keep all records, and receive all recommendations and suggestions.
9. To have charge of the details of all safety work.
10. To investigate all accidents.
11. To make weekly inspections and reports of the above conditions in the plant on forms provided for the purpose.

Workmen's Committees, consisting of three or more workmen, appointed and changed periodically, holding weekly meetings, should have the following duties:

1. To make inspections and reports of the safety conditions in and about the plant in their several departments, using forms provided for the purpose.
2. To investigate all accidents; and consider, in each case, methods of preventing a repetition.
3. To caution and warn fellow-workmen against unsafe practices.
4. To send all suggestions and recommendations to the safety department.

The duties of Foremen should be:

1. To enforce all rules and regulations.
2. To investigate and report all accidents.
3. To instruct the men, especially the new men, how to perform their work in a safe and efficient manner.
4. To caution the men against the dangers incident to their work, and the hazards which surround them.
5. To eliminate all unsafe practices.

6. To make weekly inspections in their departments, and submit reports on forms provided for that purpose.

7. To consider themselves held personally responsible for all preventable accidents in their departments.

8. To hold monthly meetings for the discussion of all matters pertaining to safety, sanitation, welfare, and efficiency.

The following outline of the safety organization of the United States Steel Corporation will prove of value:

OUTLINE OF SAFETY ORGANIZATION

I. United States Steel Corporation. — Committee of Safety.

Casualty managers of all subsidiary companies called together May, 1906, to discuss accident prevention.

Subsidiary companies actively took up safety work by detailing special men for the work.

Committee of Safety organized in March, 1908.

An officer of the Steel Corporation acts as chairman and seven other members represent the larger subsidiary companies.

Meets quarterly, either in New York or at one of the plants or mines.

Conducts inspections by having an inspector from one company inspect another company's operations.

Also makes inspections personally.

Studies all serious accidents and makes recommendations against further occurrences, not alone to the company in whose works the accident happened, but to all companies.

Passes upon safety devices and makes recommendations as to their use.

SUBSIDIARY COMPANY

Safety Committees

II. Central Safety Committees.

Organized shortly after the Steel Corporation Committee.

Made up of important officials from each of the plants, mines or railroad divisions.

Meet monthly.

Duties similar to the Steel Corporation Safety Committee, but each with reference to its particular company only.

Conduct inter-mill inspections.

III. Plant Safety Committees.

Organized shortly after Steel Corporation Committee.

Made up of important officials of the plant.

Meet monthly or weekly, and in some cases daily.

Make regular inspections of the plant.

Duties similar to those of the Central Safety Committee, but each with reference to its particular plant only.

IV. Department and Special Committees.

Organized shortly after Steel Corporation Safety Committee.

Made up of foremen, master mechanics and skilled workmen.

Meet weekly or monthly as the case may be.

Make periodical inspections of the plant.

Make special investigations of particular problems.

V. Workmen's Safety Committees.

Organized shortly after Steel Corporation Safety Committee.

Usually consist of three members from the rank and file of the mill.

Members changed periodically so that each man in a plant shall serve upon the committee in due time.

Meet monthly, in some cases weekly.

Make regular inspections of the plant or department.

Investigate accidents that have happened, and recommend means of preventing similar accidents.

4,678 Men Served on these Committees During 1912

Organization of Sanitary Work in United States Steel Corporation.

The work in sanitation has been organized in a manner almost identical with the safety organization, except that the Sanitation Committee is chosen from among the Presidents of the subsidiary companies, with an officer of the United States Steel Corporation as one of its members. This Committee administers the work through a sub-committee composed largely of technical representatives from each of the subsidiary companies designated by the Presidents of their respective companies. In this work, trained sanitary engineers and experts from outside the United States Steel Corporation organization are employed as occasion arises, and in some cases have been attached permanently to the organization of certain of the subsidiary companies.

The New York Central Lines, in addition to the General Safety Committees, one for lines east and one for lines west, have Division Safety Committees and Shop Safety Committees as follows:

Division and Shop Safety Committees

The Division Safety Committee on each Division consists of the Superintendent as Chairman, Division officials, and the following employees:

Yardmaster	Fireman	Bridgeman
Road Conductor	Brakeman	Carman
Yard Conductor	Agent	Signalman
Engineman	Trackman	Shopman

The Shop Safety Committee in principal shops consists of Shop Superintendent as Chairman, other officials, and a

Machinist	Car Repairer
Boiler Maker	Painter
Blacksmith	

"The foregoing organization is intended to secure more vigilance and co-operation by all employees in preventing personal injuries of every character. It shall be the duty of the Division and Shop Committees to investigate personal injuries which may occur in their respective jurisdictions and apply, where possible, within their authority, necessary remedies to prevent a recurrence; also investigate all dangerous conditions and improper practices which might contribute to accidents, and apply corrective measures where possible."

(Signed) A. H. SMITH, *Vice President*,
New York Central Lines.

The outline of the safety organization of the Oliver Iron Mining Company is as follows:

- Central Safety Committee (U. S. Steel Corporation)
  - General Safety Committee (Oliver Iron Mining Co.)
    - Gen. Supts.
    - Gen. Mine Inspector
    - District Committees
      - Mechanical
      - Open Pit
      - Underground
      - Safety Inspector

The safety organization of the Cleveland Cliffs Iron Co. is as follows:

- Central Safety Committee
  - Committee of soft ore foremen
  - Committee of hard ore foremen
    - First Aid Teams
    - Helmet Teams
    - Safety Committee for each mine

The First Aid Teams and Helmet Teams hold frequent drills which are carried out as if an accident or disaster had actually occurred.

Some of the larger mining companies maintain schools for the free instruction of the miners in arithmetic, elementary geometry, English, mining methods, mining rules, safety and first aid work. This educational work results directly in increased efficiency and safety.

The latest developments in accident prevention methods, as carried out by the Illinois Steel Company, are as follows:

ORGANIZATION

General Central Committee of Safety and Sanitation. — Executive charge of campaign — study accidents and devise means for prevention. Formulate rules for construction and operation. Devise guards for dangerous places. Devise plans and schemes for interesting and educating men in accident prevention.

Plant Central Committee of Safety and Sanitation. — Executive charge of Plant campaign — report to General Central Committee results and new schemes.

Special Sub-Committees of Safety and Sanitation. — On lighting — sanitation — construction — special hazards — hoisting equipment, etc. — reporting to General Central or Plant Central Committees.

Departmental Safety Committees. — Executive charge of departmental campaign — report results and schemes to Plant Central Committee.

Safety Inspector. — Secretary, Plant Central Committee. — General promoter of accident prevention campaign — keeps records of all meetings held on plant, inspections, accidents, personal injury settlements, and all records incident to the foregoing.

EDUCATION

Rule Books. — For foremen, covering construction and operating rules, printed in English only.

For workmen, covering operating rules only, printed in English and foreign languages.

Safety Buttons. — Foremen must pass examination on Safety Rules. For efficiency of 90% or better, a "Safety First" button is awarded. Workmen also invited to take examination for button, and large numbers have done so.

Bulletin Boards. — On each plant highway and in each department, one or more installed. Material used to keep men interested in accident prevention includes stories of accidents, near accidents, newspaper clippings of accidents, lists of departments successful in keeping in Prize Class for prior month, etc. Material changed weekly.

Monthly Bulletin. — Magazine containing graphical chart of accident record of departments — pictures of how accidents happen, stories of accidents, photos of Safety devices invented by workmen, photos of Safety Committees, items of plant interest, etc.

Signs at Gateways and Roadways. — Illuminated signs displaying Safety precepts printed in foreign as well as English language, and changed periodically.

Plant Preacher. — A man versed in intricacies of foreign tongues, who calls upon Foremen to whom new men have been sent, and in conjunction with Foreman, talks to men about their duties and accident prevention. Talks to men in groups on "Safety First."

Gang Safety Man. — Each foreman appoints one or more of his men to act as Safety overseer. In addition to regular duties, this man is on the alert for dangerous conditions and practices, reporting same to his foreman. Man is given "Safety Man" badge.

Division Safety Men in Departments. — Department is divided into divisions. Division head's work keeps him in the narrow confines of his division

practically all of the time. He is informed of every man under his jurisdiction, and is responsible for the safety of every man under him. He must assure himself that working conditions are safe; that dangerous practices are eliminated, that every man in his division understands Safety and Sanitation Regulations and conforms to them; that repair work is not undertaken until levers or switches controlling power are locked, using his own lock in conjunction with workmen's locks; must see that conditions are safe before machinery is started again. Must not leave his division for any purpose without reporting to his substitute or Assistant Superintendent of department. Must watch every job and see that everything is done with the thought of " Safety First." May shut down the division if necessary for Safety. Must report immediately to superiors any disregard of first warning. All workmen must notify division man before doing work in a division. Names of division heads placed on Bulletin Boards so that all will know them. Near accidents must be reported immediately to division head, who in turn reports to Assistant Superintendent.

GENERAL MEETING OF DEPARTMENT SAFETY MEN AND WORKMEN

Held in a Safety Hall. All accidents causing loss of time are read and analyzed by men as to whether trade risk, Company's negligence or workmen's negligence; the analysis also being sub-divided into appropriate branches under these headings. Discussion of inspections, reports of dangerous practices discovered, and of near accidents, etc. Meetings monthly.

Meetings in Departments under supervision of Department Safety Committee.

Announcement and list of points for discussion made by Chairman of Department Committee.

PRIZES

Articles advertising the " Safety First" idea.

When a department is successful in meeting certain fixed requirements in accident prevention during any one month, each man in that department receives a " Safety First" token bearing the Company's monogram and the slogan " Safety First."

SANITATION

There is a great deal in the psychology of accident prevention — conditions under which men work are material; pleasant surroundings and proper conditions make for better and more careful workmen.

OUTSIDE OF PLANTS

Carrying the Movement into the Home.

Through the Schools. — Engage motion picture theaters — street car company furnish transportation to same for all children — program of motion pictures on Safety and stereopticon slides.

Through the Church. — Banquet to all Clergy — stereopticon slides, motion pictures and talks on Safety. Decide on certain day to be Safety Sunday, when sermons will be on Safety.

THROUGH SOCIAL CENTERS, WORKMEN'S CLUBS, Y. M. C. A.'S

Class in Domestic Science — model kitchen using simple utensils, such as are in homes of the poor.

Class in languages, mathematics and mechanics.

Library and reading rooms.

Visiting nurse.

Gymnasium work and sports.

Playgrounds with instructor.

Flower and Vegetable Gardens — provide and prepare ground, plot or assign ground, provide seeds, provide watchman, if necessary, and provide prizes.

ARRANGE FOR A DAY TO BE SET ASIDE AS "SAFETY DAY"

PROCLAMATION OF MAYOR — EXERCISES IN SCHOOLS

Parade and provide badges and special caps and banners. End with picnic and safety exhibit.

CHAPTER III

GENERAL OBSERVATIONS

Guarding Machinery. — The employer's first duty is to provide adequate and effective safeguards and safety devices for all dangerous machinery and workplaces. Machinery should be made "fool-proof" in so far as it is practicable to do so. It is for the employer's interest, as well as for the interest of his employees, to maintain safe conditions in his factory. Otherwise, there remains a loss of efficiency among employees, and a loss of loyalty to duty and faithfulness to employer; for no employee can have confidence in an employer who keeps the way open for maimed limbs and lost lives. The safeguarding of dangerous machinery and workplaces is one of the best investments that an employer can make.

Guards should be designed to meet the requirements at hand. They should be substantially built, effectively protecting the workmen from injury. Poorly constructed, impractical, unsafe guards are far worse than none at all. If guards have been previously installed which are unsafe and in poor condition, they should be torn down and replaced by suitable new ones. Guards should be so constructed as not to hamper or interfere with the operation of machines.

Safeguards should only be removed in case of necessity, such as for repairing, altering, testing, oiling and cleaning. As soon as this work has been completed, they should be immediately replaced. When a guard is removed from a machine, a warning sign, forbidding anyone to operate the machine, should be hung in a conspicuous place. No one should be allowed to use the machine until the guard has been replaced.

There are a great many varieties of safeguards. Belt and pulleys, friction clutches, and other similar dangerou

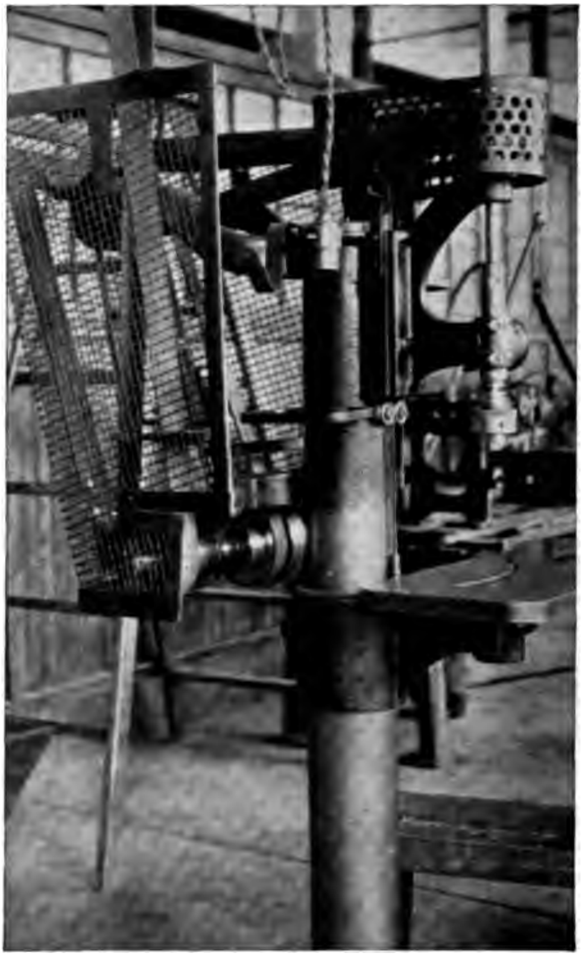


Fig. 4
Vertical and horizontal belt guards of folded sheet metal and wire mesh, and perforated metal, applied to a vertical drill.
Courtesy Bausch & Lomb Optical Company.

moving parts, are usually best guarded by enclosures (angle iron, filled in with wire mesh, sheet metal, expande

ıetal or perforated metal. Hinged lids or doors should e employed where it is necessary to obtain access to

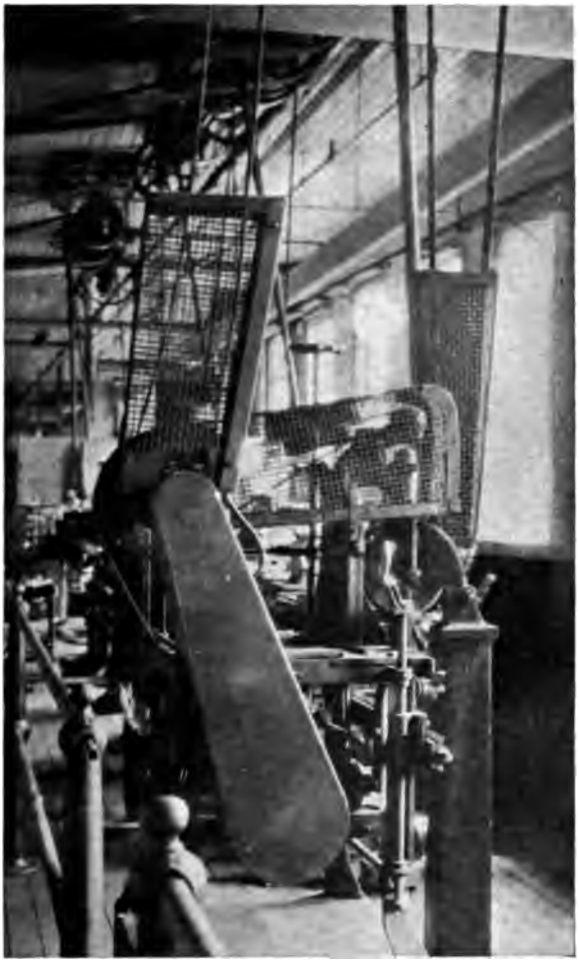


FIG. 5
Inclined, vertical and horizontal belt guards of wire mesh and sheet metal applied to a saw grinder.
Courtesy Bausch & Lomb Optical Company.

ıoving parts, in order to avoid the necessity of removing ıe entire guard. Wire mesh and expanded metal guards

have the advantage that the moving parts of machines are always visible; whereas, sheet metal obscures the view. On the other hand, as in the case of cotton mills, wire mesh collects a great quantity of waste cotton, which is constantly floating in the air, thus increasing the danger of fire. Perforated sheet metal may also be advantageously used for many purposes. Each type of these guards should be selected to meet the needs of any given condition. Chicken wire should never be used, as it easily bulges when pressure is applied. As a rule, wooden frame guards should be avoided. They are usually built in a clumsy manner, and often prove insecure. The open spaces in wire mesh, or perforated sheet metal, should be small enough to prevent a hand or finger from being pushed into any moving parts of machinery.

All dangerous gears, chains and sprockets, belts and pulleys, shafting, spindles, friction clutches, balance wheels, and revolving and reciprocating parts of machinery, should be completely safeguarded. No projecting set screws, keys, or unsafe couplings with projecting nuts and bolt ends, should be allowed on shafting.

The operating points of all dangerous machines, such as circular saws, jointers, shapers, rolls, cutting machines, shears, punching and stamping presses, etc., should be protected with suitable safety devices to prevent workmen from being injured.

Pipe railing, being more durable and substantial, should be used in preference to wooden railing.

Draftsmen should be required to check every drawing for safety. Prospective purchasers of machinery should demand specifications which provide for adequate safeguards.

The laws in each state should compel makers of machinery to install guards on all gears, chains and sprockets, and other dangerous moving parts. This would be a significant advancement toward the elimination of needless accidents. Guards of this nature could be made and

attached much cheaper by the maker, than by the manufacturer who uses this machinery.

FIG. 6
Inclined belt guards of angle iron and expanded metal applied to a wood planer and circular rip saw.
Courtesy Goulds Manufacturing Company.

Danger Signs. — Danger signs play an important part in warning workmen of dangerous machinery and appara-

tus, and unsafe workplaces. The display of danger signs, however, should not be overdone. Warnings on machinery and apparatus, which are not especially hazardous, lessen the effect of warnings at really dangerous points. Exceptionally dangerous machinery, apparatus, and workplaces should, however, be called to the attention of workmen by suitable warning signs, placed in conspicuous positions. These signs should be printed in as many languages as are spoken by the employees. They should be used in any place where unusual danger exists, and where the real danger is not apparent.

The word "DANGER" is very effective for all who speak English. When the sign is once explained, it also stands as a word picture to foreigners. The word should be printed in capitals, viz: "DANGER" but not "Danger." The latter

FIG. 7
Danger and warning signs.

method of printing is not forceful. There should be no embellishments on the plain "DANGER" sign. As a rule, pictorial signs should be avoided. Such designs detract the workmen's attention from the quick warning which danger

signs are intended to convey. The workman is apt to gaze on the picture, forgetting the real warning for the moment.

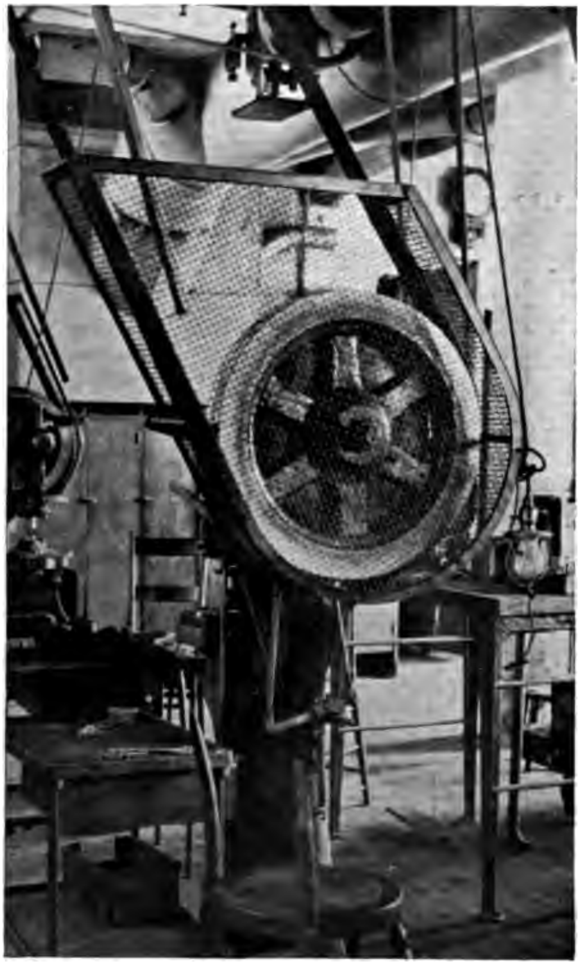


FIG. 8
Guard of wire mesh and folded sheet metal for inclined belt and balance wheel of punch press.

Courtesy Bausch & Lomb Optical Company.

A simple red disc has been generally adopted and accepted as the universal danger sign. It would seem better,

however, to use the word "DANGER" in connection with it. The simple "DANGER" sign conveys the idea of caution and danger more forcibly than the plain red disc.

When necessary for a special purpose, other words may be added or substituted to emphasize a specific hazard. The wording should be as brief as possible, and to the point; otherwise, the effect of the warning will be lost. Letters should be large enough to be readily distinguished by an approaching workman before the danger point is neared.

Signs, which are visible from more than one side, should have the warning printed upon both sides. Warning signs should be kept on hand for immediate use when occasion arises.

Red has been the universal danger color for many years. White letters on a red background make a strong contrast. It may be argued that red should not be retained as the universal danger color, on account of the fact that some people cannot distinguish it. The red color, however, has sufficient advantages and precedent to warrant continuance of its use as the universal danger color.

Clothing. — Employees should be instructed to wear no loose, baggy, torn clothing, flowing skirts or aprons, unbuttoned jumpers, loose suspender straps, gloves, and flowing ties, when working about machinery. Females should be cautioned to do their hair tightly, or wear caps. Ornaments, such as finger rings, bracelets and necklaces, should not be worn. Many accidents result from the clothing or ornaments, worn by employees, being caught in machinery, drawing the victim in, and causing a serious or fatal injury. Comparatively tight fitting clothing is essential.

It is of great importance to caution the workmen to wear shoes which are properly soled. They should not be allowed to wear too thin. Thick soles prevent accidents from stepping on protruding nails in loose boards, broken glass, metal scrap and other débris. They also prevent the feet from being burned or blistered by acids or other

chemicals and hot floors or articles. Workmen in foundries should be required to wear "Congress" shoes to prevent burns from spilled molten metal. If ordinary shoes are worn, the spattered metal may catch in the eyelets, lacings, or buttonholes and burn through the leather into the flesh.

Congested Workplaces. — Another factor, bearing upon the causation of accidents, is that of congested workplaces.

FIG. 9
Safe and sanitary clothing.
Courtesy Beech-Nut Packing Company.

Accidents are bound to occur where machinery is installed without sufficient space between the machines, or machines and the walls. Floor space should not be economized at the expense of safety to the workers. Floors, passageways, exits, stairways, and fire escapes should be kept clear of all loose material and accumulations. There should be sufficient clearance about all machinery to render a safe passage for workmen. Machines should not be crowded together, as this greatly increases the hazard.

Ignorance. — Many accidents may be attributed to ignorance on the part of workmen to the dangers of their work and the hazards which surround them. This can be overcome by educating employees through safety committees in each plant. Employees should be taught to be watchful and cautious of their own safety, and that of their fellow-workmen. They should be taught to think for themselves, and not indulge in any needless risks nor take unnecessary chances. They should be forbidden to fool during working hours.

Intoxicants. — Although comparatively little attention is usually given to the effect of intoxicating liquor on the causation of accidents, this agent has a much more important influence in this connection than is generally believed. The influence of intoxicants is, of course, frequently indirect. Many accidents, however, may be directly attributed to active intoxication. Habitual use of intoxicants affects the nervous system and impairs the health. It greatly reduces the resistant power of the body to disease. The brain is detrimentally affected, the mind becomes excitable, and the power to think clearly is weakened.

An active campaign should be carried on by every company to eliminate, so far as possible, the use of intoxicants by employees. In order to secure results, this must necessarily take the form of individual effort on the part of the management. Workmen should be personally and privately urged by the manager or superintendent to refrain from drinking, especially before coming to work and during the noon hour. They should also be requested to remain away from work in case they have been drinking heavily the previous night. In no case should employees be allowed to use intoxicating liquor on the premises. Pressure should be brought to bear toward the elimination of nearby saloons. Attractive lunchrooms and club houses should be maintained and food sold at cost, making it unnecessary for employees to go elsewhere during the daily recess. Every company should clearly impress upon

the mind of each workman that those who abstain from the use of intoxicating liquor will be first considered for promotion.

Fatigue. — Many accidents are due to fatigue and brain-fag, caused by overwork and too long hours. Men who work about dangerous machinery should have as short hours as possible, consistent with good management. Long hours and overwork affect the brain. They make the employee dull, unable to think quickly, and therefore inefficient. When a workman is overtired, he cannot remain constantly on the alert, nor can he remain duly cautious of his own or his fellow-workmen's safety. Such a condition should not exist in any factory, but, practically, this condition is a very general one.

Illness. — Employees, who become sick when they are at work, often continue working, rather than submit to taking time off. Again, they often go to work when ill. In such a condition, a workman has not the full use of his normal faculties and, therefore, is unduly susceptible to danger. This condition is much the same as fatigue. Employees that become ill should be instructed to leave their work and report to the doctor at once. Some workmen will, of course, profess illness, who are merely feigning, but proper management should satisfactorily adjust these conditions.

Thoughtlessness and Carelessness. — A large proportion of accidents are caused by thoughtlessness on the part of workmen. Many call it carelessness. It is really a combination of both. The thoughtless or careless workman is always in trouble; he is inefficient, and frequently injured. He fails to think before he acts. A form of this thoughtlessness may be characterized as absentmindedness.

Concentration. — Workmen should be taught concentration of the mind and eye. The workman who is continually looking about the workroom at other persons or objects, or who is day-dreaming much of the time, is the one that is most likely to meet disaster. The operator of a

dangerous machine whose mind or eye is distracted from his work, even for a fraction of a second, may become caught by moving parts of the machine. The result is either a serious or a fatal injury. Concentration can only be acquired by practice. The workmen's attention should not be distracted by unnecessary noises or extraordinary sights, such as might be made by fooling, whistling and shouting, or by other needless causes.

Instruction. — Workmen should be carefully instructed by their foreman in the correct methods of performing their work in a safe and efficient manner. Especially should the new man be warned of the dangers incident to the work, and the hazards which surround him. In this way he will learn to look out for himself. Otherwise, he may be injured through ignorance concerning the dangers to which he is exposed. The workman, who is not properly warned and instructed, does not have a fair chance to protect himself from injury. This instruction is a duty that necessarily falls upon the foreman. He should not fail in giving necessary warnings to the men under his control.

Discipline. — Workmen should be reached through persuasive, rather than through mandatory methods. The foreman should show the workman why he should obey any rule, and the danger to himself and other employees if he disobeys. The foreman should reason with the workmen through the art of suggestion, making the workman freely admit the desirability of any rule. Workmen should be especially warned not to remove safeguards from machinery without permission from the foreman. They should be instructed to replace the safeguards before the machinery is put in operation. Foremen should watch to see if their instructions are obeyed. If a workman continues to disobey instructions, he should be brought before the superintendent and manager for serious talk. If he continues to wilfully disobey instructions, he should then be discharged.

Inspection. — The only way in which buildings, fire apparatus, machinery, safeguards and workplaces can be maintained in a safe condition is by frequent and thorough inspection by competent men. Every large company should employ at least one trained inspector whose entire time should be devoted to this work. Periodical inspections should also be made by workmen representing workmen's committees, and by foremen, in their several departments.

Insurance companies usually offer the best type of inspection service. The majority of their inspectors are men who have been trained for this work, and who have gained considerable experience of a varied character. They know what advancement has been made by the more progressive companies in all classes of work, how accidents are most likely to occur, and where safeguards should be applied. Their counsel should be carefully considered by employers.

Inspections by representatives of insurance companies, however, are made comparatively infrequently. These inspectors are bound to overlook many minor unsafe conditions which should not exist. Their inspections do not cover unsafe practices to any extent. For these reasons, it is of prime importance for each company to maintain its own inspection department. Safety in any factory or workplace depends largely upon frequent, conscientious and careful inspection.

Education of Children and Students. — Children should be educated in the art of self-preservation from public and industrial dangers. This can be most advantageously attained through the schools. Children can be best interested by motion pictures of dangerous practices, and through illustrated lectures. This form of education should comprise matters pertaining to safety, sanitation, and hygiene. Little has yet been done in this respect, but much should be accomplished in this direction in the future.

This education should extend to universities, colleges, and technical schools. A regular course in safety, sanitation and hygiene should be formed. Many of these educational institutions now maintain courses in the two latter subjects, but practically none touches upon matters of public and industrial safety. The safety problem is daily assuming more importance in industrial work and public life. This is a subject which has been sadly neglected, but which should now receive close attention.

Education of the Public. — The education of the public is a matter that is now being actively promoted by many transportation and traction companies, chambers of commerce, societies of various kinds, and other institutions. Progressive railroad companies show motion picture plays in towns and cities for the benefit of employees. The public is invited to attend, admission being free to all. The picture plays, stereopticon views, and talks cover many hazards of the rail. The public may be reached through the press, by prominent posters in stations containing precautions which passengers should observe, through time tables, and by various other means.

Members of automobile and other clubs may be reached through literature and warnings posted on bulletin boards or distributed in circulars. Municipalities should proclaim a "Safety First" day which should be celebrated by a safety parade and other features. Local safety exhibits should be held, and so on.

The National Exposition of Safety and Sanitation, held under the auspices of the American Museum of Safety and Sanitation of New York City, is the best annual safety exposition in this country. Here large manufacturing companies exhibit their safety devices each year. Railroad companies, mining companies, and insurance companies also have exhibits at this exposition. Motion pictures of various hazards are shown at this time, and many interesting talks are given by prominent men who are interested in safety work.

The American Museum of Safety and Sanitation of New York has many interesting safety devices on exhibition throughout the year. Prominent companies have contributed models of safety devices. Photographs, drawings, and other objects of interest may be seen here. Admission is free to all.

CHAPTER IV

BUILDINGS AND FIRE HAZARD

THESE two subjects are so closely allied that it is convenient to treat them under one heading. Although the subject of fire prevention lies primarily within the province of fire underwriters and experts, it does, however, come within the scope of accident prevention. Therefore, it is proposed to set forth the general underlying principles of fire protection and prevention, although no attempt will be made to cover the topic in detail. For further information upon the subject of fire prevention, reference should be made to the specifications and requirements of the National Board of Fire Underwriters, and to other complete works.

The large fires of the past, entailing an enormous loss of life and property, are convincing evidence of the urgent need of adequate fire protection in our towns and cities. Many of the buildings, now in use for manufacturing purposes in our largest cities, are fire traps of the worst kind. Should a fire start in one of these buildings, there would be little chance of the workers escaping. The percentage of manufacturing buildings in our large cities without adequate fire protection is amazingly large. This is a condition which should not exist. As it does exist, however, laws relative to fire protection can hardly be too stringent or too rigidly enforced.

Special attention should be given to fire protection wherever new building is contemplated. Equal attention should be given to making existing buildings, in which labor is employed, as safe from fire hazards as possible. All contemplated buildings, over one story in height, in

which labor is to be employed, should be built of fireproof or slow-burning construction. Wherever practicable, the height of new factory buildings should be limited to four stories, especially if the buildings are not to be of fireproof construction. This limitation will effectively minimize the danger of loss of life in case of fire.

Construction. — Fireproof construction specifications call for non-combustible foundations, walls, floors, ceilings, and roofs. Slow-burning (mill) construction specifications call for stone, brick or concrete walls; stone or concrete foundations; floors of planks at least $2\frac{3}{4}''$ thick on beams (without joists) on posts, covered with a $\frac{3}{4}''$ top flooring laid diagonally or crossways; roofs of planks at least $2\frac{1}{4}''$ thick laid flat, except for the pitch necessary for proper drainage. The planking in the floor and roof should be splined or tongued and grooved. Fireproof construction is, of course, preferable from the standpoint of safety and durability, and will usually well repay any extra cost of construction.

Foundations. — The ground for the foundations of new buildings of considerable size is usually tested previous to construction operations. If necessary, piling, capped with concrete footings, should be used. Any possibility of the settling of the foundations should be eliminated. Foundations sometimes settle enough to so weaken the structure, where floors are heavily loaded, that the collapse of the building is a startling possibility, and occasionally a reality. Buildings should not be supported by wooden posts, or even partially supported by them, when projecting over a river bank or other depression. The danger from fire and unnoticed wood decay is too great to allow the use of wooden posts as a supporting medium. All foundations should be substantially built of stone or reinforced concrete.

Fire Walls. — It is frequently desirable or necessary, on account of the different usages for which parts of a building are designed, to separate departments or sections

by means of fire walls. These should be constructed of brick, tile, or reinforced concrete at least 12″ thick. The walls should extend from the basement to a height of 3 feet above the roof, and should be provided with a non-combustible durable coping. The purpose of the fire wall is, of course, to confine a fire to the section in which it originates.

Floors. — Floors should be free from protruding nails, holes and splinters. They should not be uneven or slippery. Where floors will necessarily be wet, due to the nature of the work, they should be so graded as to drain properly. Floors of boiler houses should never be constructed of wood. They should be built of concrete, brick or stone. Reinforced concrete floors, covered with a hardwood top flooring, are preferable for most purposes in factory or office buildings. Sand should not be used on floors in an effort to prevent slipping, as it enhances the possibility of slipping, rather than prevents it. Powdered resin should be used instead. Floors should constantly be kept free from the accumulation of waste materials, nails, tacks and obstructions. They should never be overloaded, and if this is suspected or detected, they should be relieved without delay. Floors are built for a definite capacity which should never be exceeded.

Floor openings, including stair and hoistway openings, should be protected with a standard handrailing 3½ feet high with a toeboard 6″ high at the bottom, and an intermediate horizontal member between the two. (Fig. 10.) Where it is impracticable to guard floor openings with a permanent railing, a removable railing may be used, or the opening may be provided with a hinged cover.

Stairways and Elevator Shafts. — Main stairways should be constructed of iron or reinforced concrete with safety treads. The stairway should preferably be built in a fireproof tower on the outside of, and adjoining, the building. The tower should be of brick or reinforced concrete, with walls at least 12″ thick, extending 3 feet above the roof.

The tower should be separated from the building by a complete fire wall, with entrances at the side of the tower, connected to the entrances of the building by iron plat-

FIG. 10
Properly guarded stairway opening.
Courtesy Goulds Manufacturing Company.

forms of the fire escape type. This makes a semi-indirect means of entrance or exit, and assures a safe means of escape when a fire is raging in the building. The doors of fire towers, if of the swing type, should open inward except

the exit doors at the bottom. Windows in fire towers should be of wire glass in metal frames.

Elevator shafts should be built of fireproof construction, similarly to stairway towers. If an elevator shaft adjoins a stairway, they should be separated by a fire wall. Both stairways and elevator shafts should be equipped with automatic fire doors. In case the elevator shaft is not thus equipped, it should be provided with automatic fireproof trap doors at each floor.

Each stairway should be equipped with a standard handrailing on both sides, placed 3 feet above the center of the treads, and at least 2″ from the side wall. Open sides of stairways should always be provided with hand rails. Stairways, over 8 feet wide, should have an additional hand rail in the center. Risers should not be over 8″ in height, and treads should be at least 10″ wide. Safety treads, of non-slip material, should be used on main stairways. If wooden hand rails are used, they should be smooth and free from splinters. All stairways should be at least 4 feet wide. Main stairways should be at least 6 feet wide. Stairways should be kept free from obstructions at all times. No materials or articles should be hung on the sides of the stairways. No one should be allowed to pile material of any kind on stairways. They should be well lighted at all times, during working hours. Stairways should never be steeply inclined. An inclination of 30 degrees from the horizontal is a safe average.

Doors. — Door openings should be equipped with standard automatic fire doors, preferably of the sliding type, on each side of the wall. Where sliding doors are used, they should preferably recede in a complete housing when opened. Often, material is carelessly piled next the wall, directly behind the fire door, thus making it impossible, in an emergency, to open the door from the opposite side. A suitable housing will, however, guard against this contingency. All swing doors, used for exit, should open outward. Double swing doors, in public or office buildings,

hotels, and restaurants, should be built with the upper panels of glass, which will enable anyone to see another approaching from the opposite side, thereby avoiding a possible collision. The counterweights of all doors should be encased. Fire doors should always be closed at night, and on Sundays and holidays. They should be held, when open, by means of fusible links. When the heat becomes abnormal, as in the case of a fire, they will thus close automatically. Automatic fire doors should be frequently inspected to make sure that they are in working order.

Fire Escapes. — Fire escapes should lead directly from each section of the building. They should be of very substantial iron construction. They should be constructed with treads, and should not be of the ladder variety. Often, partially incapacitated workmen are employed who could not use a ladder escape, on account of the loss of a hand or an arm, or for other reasons. The space between the handrailing and treads or platform should be filled in with substantial iron grille-work. The railing should be at least 3½ feet high to prevent anyone falling off the fire escape. Exit to fire escapes should be obtained by means of a door, opening outward; never by a window. The platform level of the fire escape should be the same as that of the floor which it is designed to serve. The intervening threshold should not exceed 2″ in height. If the exit to any escape is obtained by means of a window, the window should be converted into a door 6½ feet high, with the bottom of the door nearly level with the platform of the fire escape. A short stairway, provided with a hand rail on each side, should lead from the floor of the workroom to the threshold of this doorway. If escape is obtained by means of one roof to another roof below, a stairway of iron, with hand rails on each side should connect the two. All ladders leading to roofs, for fire-fighting purposes, should be permanently constructed, and securely fastened at the top and bottom. They should be of iron, not wood.

Exits. — Conspicuous "EXIT" signs, with white letters on a bright green background, should be placed at all places of exit on each floor of every building. (Fig. 11.) The exits should also be provided with a green light, to be used when daylight is insufficient to allow a clear view of the sign. No obstructions should be allowed to accumulate at or near any exit. Exits and passageways should be clear at all times during working hours. Exit doors should be kept unlocked at all times when employees are working in the building. Care should be taken to see that there are a sufficient number of exits.

FIG. 11
Properly marked exit to fireproof stairway tower. A green glass electric bulb is used to display a green light after dark.

Courtesy Utica Willowvale Bleaching Co.

Windows. — All windows above or below fire escapes, in fire towers, skylights, elevator shafts, saw-tooth roofs, and for a distance of at least 10 feet in the outer walls of the building on either side of the fire walls, should be constructed of wire glass in metal frames. These windows withstand a great amount of heat and pressure, and are not easily broken. Windows should be frequently washed to prevent the accumulation of dust, which greatly reduces

the volume of light that should be utilized. Windows, at intermediate stair landings, should be guarded on the inside with a substantial iron grating, grille-work, or bars, to prevent anyone from plunging headlong through the windows, in case he should accidentally slip on the stairs. Windows, which are not constructed of wire glass, should be equipped with fireproof shutters. Employees should be forbidden to throw articles of any kind through the windows.

Roofs. — Roofs should be kept free of loose material at all times, otherwise a strong wind might blow it down, injuring or killing someone. For this reason all advertising signs should be substantially constructed, and frequently inspected to insure their safe condition. Where walls are not extended above flat roofs, a substantial railing and toeboard should be constructed to surround the roof. This will prevent anyone or any loose material from falling.

Tanks. — All elevated tanks, whether on a roof or an individual support, should be provided with a substantial platform, guarded with a railing and toeboard, to afford a safe means of inspection of all parts. Ladders to tanks should be substantially secured at the top and bottom. Ladders to platforms on individual supports should be caged. During a long climb, the inspector or workman can thus find a safe means of resting, and at the same time is protected from falling. It is advisable to build a trap door in the platform about the tank. This door may be closed, thus preventing the inspector from accidentally falling into an open hole. All parts of tanks and supports should be frequently inspected for defects and deterioration.

Elevated Footways, Runways and Platforms. — Where elevated runways, footways, or platforms are over 4 feet above the level of the ground or floor, they should be guarded with a standard railing and toeboard. This applies, also, to footways about machinery, shafting, footbridges, and trestles. Openings in the side walls of build-

ings to yard arms, or overlooking areaways, driveways, waterways, or platforms should be guarded with vertically sliding gates, or by means of horizontal keeper bars, pivoted at one end. These gates or bars should be kept closed at all times when the opening is not in use.

Boiler and Engine Houses. — Current practice is to build boiler and engine houses entirely separate from the main buildings, and from each other. They should be separated from the main buildings by at least 25 feet. This is the safest plan, on account of boiler and flywheel explosions. Where they are so separated, there is not nearly so much danger to employees in the main buildings. It is bad practice to install boilers and engines in the main buildings. If they are in houses adjoining the main buildings, the houses should be separated from the main buildings by means of a fire wall and fire door. There should be at least two exits in each boiler or engine house.

Stacks. — Smokestacks should be of brick, reinforced concrete, or self-supporting steel. Safety caged ladders should be used on stacks. The foundations should be sufficiently large and substantial to prevent settling. It is advisable to equip stacks and chimneys, steeples, flagpoles, peaked roofs, and isolated buildings with lightning arresters to prevent damage from this element. The conductors should be well grounded, preferably to water piping. They should be coated with a protection from corrosion, and substantially secured and insulated from that which they are to protect. Conductors should have no sharp curves or bends, and should have as few joints as possible. Stacks and chimneys should be occasionally inspected at regular intervals for defects, such as cracks and loose bricks. Cracks should be filled and watched, and all loose bricks reset. Steel stacks should be regularly inspected for corrosion, and should be kept covered with a thick coat of paint.

Electrical Apparatus. — All electrical apparatus should be installed with due regard to the fire hazard involved.

The voltage should be as low as is consistent with working requirements. All wiring should be run in metal pipe conduits, and not in wooden moulding nor upon knobs and cleats. Great care should be taken not to place electrical apparatus where it can come in contact with inflammable or explosive material. Spark arresters should be placed about open arc lights. Incandescent electric lamps should never be placed upon, or draped with, combustible material. Paper lamp shades should not be used. Flexible cords should not be hung on nails or metal parts of machines. Fuses should never be replaced with wire. They should be placed in fireproof metal boxes which should be kept closed. Fires on or about electrical apparatus should never be extinguished with water. This method should never be attempted. Instead, powder fire extinguishers should be used. Employees should be warned of the danger of using a stream of water, or other liquid, in connection with a fire on electrical apparatus, as water is a good conductor of electricity. Deaths have resulted from this form of carelessness.

Automatic Sprinklers. — Automatic sprinklers have come into general use for purposes of fire protection, and they have since proven their worth. All factory buildings should be equipped throughout with automatic sprinklers. The system may be connected with a tank, standpipe, reservoir, pump, or public main. In any case, the system should be so installed as to be of service during cold weather. Precautions should be taken to prevent any possibility of the water supply being cut off or disabled from exposure. Each automatic sprinkler installation should be equipped with an alarm valve, so constructed that a flow of water through the system will operate an electrical or mechanical gong. It is often advantageous to have the alarm system connected to a central station or to the public fire department. A dry pipe sprinkler system should only be used in cases where a wet pipe system is impracticable, as in buildings which have no heating system.

Hose. — Where hydrants are used, a suitable hose house should be constructed containing a sufficient length of hose to reach any building which it is designed to serve. The line of hose should be kept properly folded and in good condition. The hose house should be kept unlocked at all times. Hose stations should be located at convenient points where they will be most effective.

Auxiliaries. — Hand drawn chemical carriages should be maintained when needed for some special purpose. Chemical extinguishers should be located at many convenient places about the factory, in addition to the hose lines and sprinkler system. Employees should be instructed in the proper methods of using them. Water pails should be painted red, with the word "FIRE" in white printed on the outside. They should be frequently and periodically filled, on account of evaporation of the water. Pails filled with sand, or a large supply of sawdust with shovels, should be maintained where there is a possibility of gasolene or other oil becoming ignited. Heavy woolen blankets are also very useful in smothering the flames of a fire when it first starts.

Fire Alarms. — Each factory should have an efficient fire alarm system which will warn employees of danger when in the most remote parts of the plant. An adequate number of boxes and alarm gongs should be installed. The system should be tested daily, to make sure it is in perfect working order at all times. Employees should know the location of all boxes, and should be instructed in the proper method of using them in case of fire.

Fire Precautions. — Waste, oily rags, sawdust and other refuse should be placed in metal cans or receptacles provided with covers. If left lying carelessly about, oily rags and waste are apt to take fire spontaneously. Inflammable material should be stored in small piles, where possible, rather than in one large pile. No inflammable or volatile material should be allowed near any machine capable of causing a spark. Open lights should never be used in

rooms where paints, varnish, turpentine, and crude oil are used or stored, nor in rooms where explosive gases and chemicals are used. These substances should be stored in separate buildings. Vats or receptacles containing inflammable or volatile substances should be provided with close fitting covers held open by fusible chain links. The covers should be kept closed when possible. Empty boxes, barrels, kegs, and other rubbish should not be allowed to accumulate. Lighted cigar and cigarette stubs, pipe ashes, and matches should never be thrown on or near rubbish piles, or in other dangerous places where they might start a fire. Floors should constantly be swept clean where waste rapidly accumulates. All rubbish should be collected and disposed of each day.

Safety matches only should be used. Workmen should not be allowed to carry any matches, even of the safety kind, into the buildings. In this country, the use, sale and manufacture of matches containing poisonous white phosphorus is forbidden by law. Prior to this law, which went into effect several years ago, many cases of phosphorus poisoning were prevalent.

Drip pans should be placed to catch the oil drippings from machines, preventing the oil from soaking into the floor and rendering the floor slippery. Sawdust, or other combustible material, should not be used in the drip pans to absorb the oil; sand should be used instead.

Gas jets, nearer than 3 feet from a combustible ceiling, should be provided with heat deflectors, placed at least 6″ from a combustible ceiling. Gas jets should never be placed nearer than 18″ from a combustible ceiling, even when provided with heat deflectors. Combustible walls, within one foot of a gas jet, should be covered with asbestos board and tin, with an air space between this protector and the wall. The wall behind all swing jets should be similarly protected. Swing jets should be provided with stops to prevent them from swinging within one foot of the wall. Flexible rubber tube connections

should be avoided, if possible, but if they are used, the cock should be placed at the junction of the tube and the pipe, and not at the burner. No attempt should ever be made to hunt for a leak with a lighted match or other open light. The windows should be immediately opened, and the supply of gas turned off, before attempting to find the leak.

Kerosene lamps should never be filled while burning. They should be filled by the aid of daylight, and not by the aid of an artificial light, other than an electric lamp. Gasolene and naphtha lamps should never be used, as they are too dangerous. These liquids vaporize freely and are likely to be exploded. Special pains should be taken to have the rooms well ventilated, where volatile liquids are being used or stored, otherwise, the vapors will collect, endangering life and property.

Where coal stoves are used, the pipes should run directly to chimneys; never through floors or partitions. Combustible walls and ceilings about stoves should be covered with sheet metal and asbestos, with an intervening air space. Hot air and steam pipes, within one foot of combustible material or woodwork, should be similarly protected. Wood, which is in contact with hot pipes, gradually becomes charred, and is then apt to be easily ignited.

In this connection, a word of caution in the use of fireworks may not be amiss. In one city in this country, no less than eight fires were caused by fire balloons during a Fourth of July celebration. Other types of fireworks are equally dangerous, and great care should be used in handling them. Not only fires result from their careless use, but an amazing number of serious accidents as well. Shingle roofs and lumber piles should be wet down before fireworks are to be used. This is also a wise precaution to take in hot dry weather.

Explosive and Inflammable Liquids. — Gasolene, because of its general use and the growing carelessness with

which it is handled, has proven itself to be as dangerous as ordinary dynamite. The explosive power of gasolene, properly mixed with air and compressed, is enormous. Unlike the heavier petroleum products, it evaporates constantly at extremely low temperatures. It is not always necessary to ignite gasolene to explode it. Under certain atmospheric conditions, in an accumulated vapor, it is capable of spontaneous combustion. Gasolene and naphtha should be stored in strong metal tanks, vented to the outside atmosphere, at least three feet underground, and at a remote distance from other buildings. The filling connection for the main supply tank should be located away from the main buildings. The ground should slope in a direction away from the main buildings, to prevent the gasolene from running toward the buildings in case it is spilled.

All buildings, in which gasolene is used, should be of fireproof construction. No pits should be allowed in the floors. No motors or machinery, capable of causing a spark, should be allowed in the same room. If belts pass through the room in which gasolene is used, the pulleys should be effectively grounded, to prevent static electricity from accumulating on the belt and causing a spark. Belt openings in the wall should be as small as possible. Belts should be greased with acid-free glycerine every week or so. The glycerine absorbs moisture, which prevents the accumulation of static electricity on the belt, and also increases the life of the belt. In a dry atmosphere, a belt is often capable of producing an electrical spark varying from $\frac{1}{4}''$ to $1\frac{1}{2}''$ long, depending upon the size and speed of the belt. If the belt is rubbed with resinous substances, this tendency is markedly increased. Floors should be of concrete, and so sloped that any spilled gasolene will drain into removable catch pans, placed in the floor. Spilled gasolene should be immediately disposed of. If gasolene is stored in a building, which of course should always be isolated from the others, it should be kept in evaporation-proof and fireproof tanks, vented to the outside atmosphere.

Cocks, valves, and other connections should be frequently inspected for leaks and, if found, the leak should be immediately stopped and the connection made tight. No attempt should be made to hunt for a leak with an open light of any kind. The incandescent electric lamp, protected with a wire hood, is the only light that should be used for this purpose.

Powder fire extinguishers should be kept on hand, for use in extinguishing a gasolene or other oil fire. Pails of sand, woolen blankets, and sawdust are also useful. Water should never be used in an attempt to quench any oil fire. The oil floats on the surface of the water, and this only serves to spread the flames.

Strict rules regarding the methods of handling gasolene, and other similar liquids, should be enforced by the foremen. No gasolene should be issued except upon a written order from the foreman. It should always be issued in safety cans of the non-explosive type. The can should be painted a bright red color, with the word "GASOLENE" printed in white letters on the front or top. Only a few days' supply of gasolene should ever be issued, and any which is left over should be returned at night.

Gasolene should not be used in a room which is heated with anything other than hot water or steam pipes. Conspicuous "NO SMOKING" signs should be placed about the room, and this rule should be strictly enforced. No lighted matches, candles, kerosene lamps, torches, or other open lights should be tolerated in a room where gasolene is used or stored. Electric lamps, protected from breakage by wire hoods, are the only permissible lights in such places. Care should be taken to see that all cords and connections are well insulated, and that there is no danger from a short circuit.

Oil should never be poured on a fire for the purpose of making it burn rapidly. Many bad accidents have resulted from this form of carelessness. Oil may be cautiously applied in small quantities before the fire is started,

if desired, but not after. Even then, great care should be exercised in igniting the material.

Much that has been said of gasolene is applicable to other explosive, volatile, and inflammable liquids and material.

Dust Explosions. — Under certain conditions, the dust of many organic substances, such as flour, coal, starch, sugar, rice, meal, grain, bran, etc., is capable of exploding with tremendous violence. Many serious dust explosions in flour mills and coal mines have occurred from time to time, which have resulted in a large loss of life and property. The dust of the above named and similar substances becomes especially dangerous when it is suspended in the air in a finely divided state. It may also be ignited when deposited on floors, walls, ceilings, elevators, belts, shafting, machinery, etc., the resulting blaze causing an explosion. Dry wheat dust will explode when only 0.034 of an ounce is suspended in each cubic foot of air. Under the same conditions, an equal amount of coal dust forms an explosive mixture. Explosions are likely to take place in grain elevators under favorable conditions, although they usually occur in grinding and rolling mills.

Explosions are caused by sparks from grinding stones, belts, machinery, and electrical apparatus; also, by lighted matches and other open lights. Workmen should be forbidden to take matches into a mill or an elevator. The use of open lights of any kind should be strictly prohibited. Motors and electrical switches should be encased in explosion-proof enclosures. Oil switches may be used. Pulleys should be grounded to prevent static electricity from accumulating on the belts. All possible precautions should be taken to prevent the occurrence of sparks and the use of open lights. Dust explosions, in addition to the damage which they directly cause themselves, are invariably followed by serious fires.

CHAPTER V

EXIT FIRE DRILLS

ORGANIZED exit fire drills should be inaugurated, and a definite duty assigned to each employee. The foremen should take charge, and see that order is maintained in their departments. Drills should be held at least once a month, and should be called at times previously unknown to the employees. Foremen should take special pains to impress upon every employee the seriousness of the fire drills, and warn employees against the dangers of a panic. They should also impress upon the employees the safety in using the fire escapes or fire towers.

Organization. — The organization should consist of a Chief, Floor Chiefs, Room Captains, Stairway Guards, Searchers and Inspectors. The Manager or Superintendent, or other person in authority, and with the proper qualifications, should act as the Fire Chief. He should supervise all maneuvers, and select persons to fill the different positions of the organization. He should fix a time for drills, and see that the employees comply with all of the rules and regulations.

Floor Chiefs, preferably foremen, should be selected to take complete charge of each floor. They should be held personally responsible for the enforcement of all rules, and should report any employees who neglect to observe the rules. They should see that the aisles and passageways are kept clear of chairs, stock and other material. They should give orders to those under their supervision, and see that all movements are properly executed.

Room Captains should preferably be foremen, or assistant foremen, who have authority over those in their

departments. They should be selected for their ability and cool-headedness, and capacity to maintain the necessary control over employees. There should be a room captain for every fifty employees.

Stairway Guards should be selected for their strength and alertness, and capacity to act quickly in an emergency. Two men should be placed at each exit, or on each stairway. If on a stairway, one should be stationed at the top, and the other at the landing midway between the floors. Stairway Guards should take orders from the Room Captains. They should do all in their power to prevent unnecessary haste and crowding, and see that all employees march in order down the stairway to safety.

Searchers, selected for their strength and cool-headedness, should be assigned to visit toilet rooms, or other rooms in which there may be occupants who cannot hear the signal. They should also care for any employees who become hysterical or faint.

Inspectors should be appointed to make a daily examination, and fill out a report, as to the condition of all stairways, fire escapes, exits, etc. They should immediately report any defects. They should see that all exits are unlocked during working hours, and that no stairways, aisles or passageways are obstructed in any way by material, or other objects. Exits should be plainly marked.

Drills. — Every employee should know the exact location of all fire apparatus and alarms, and how to use them in case of emergency. Records should be kept of the maximum time it takes to empty each building. As soon as the alarm is sounded, employees should clear all aisles and passageways of obstructions, and then immediately form in line, either single or double file, as the circumstances recommend. If in double file, employees should link arms for mutual support. The lines should start on a motion signal. from either the Floor Chief or Room Captain, and continue on to stairways or fire escapes.

No employees, or other persons, should be permitted to attempt to secure or recover clothing, or other articles, from the lockers, cloak rooms, or elsewhere, after an alarm has been sounded.

The assignment of exits for the different floors should be based upon the relative discharging capacities, and upon a result of actual tests. In these trials, every available exit, including those reached by the way of the roof, should be considered. The greatest efficiency can only be obtained by frequent drills, and by having the foremen impress upon all of the employees the importance of complying with all rules and regulations. Frequent fire drills so accustom the employees to forming lines, and marching quickly to safety, that it becomes a habit; and when a real fire occurs, there should be little or no confusion.

CHAPTER VI

ORGANIZATION OF FIRE BRIGADES

THE organization of a fire brigade, in any plant, depends upon local conditions, and must, therefore, be organized to suit the requirements at hand. The degree of efficiency will depend largely upon the care and judgment exercised in selecting and training the men. Employees should be selected who are sober, strong, reliable, coolheaded and well posted in regard to the location of all fire apparatus, stairways, elevators and buildings in general.

The fire brigade should be organized under a constitution, with its own by-laws. Regular meetings should be held. Some special distinction should be conferred upon members; and membership should be deemed a privilege by employees.

Company organization should be designed to afford men special knowledge and experience in their respective duties. They should be so instructed and trained that they will be able to perform their duties to the best advantage, when a fire occurs.

Officers. — The brigade should consist of a chief, preferably the master mechanic or factory manager, who has a thorough knowledge of the factory and its equipment. There should also be an assistant chief, who should perform the duties of the chief in his absence, or perform other services as the chief may direct.

Shop foremen should be selected as captains of companies, and those men should be selected who are thoroughly familiar with the buildings and all fire apparatus. Every fire company should have a lieutenant, who should take charge in the absence of the captain.

Hose Company. — The hose company should consist of at least ten men, including the captain and lieutenant, in order that there may be a sufficient number to lay and operate the hose lines in a reasonable length of time. One man should be assigned to hydrant duty, and at least four men to each line of hose. No one company should operate more than two lines of hose, except under special conditions. The men selected for this work should be strong, gritty, active, reliable, and not easily subject to fatigue.

Hook and Ladder Company. — The hook and ladder company should consist of at least nine men, including a captain and lieutenant. They should be trained in placing ladders; in the handling and use of chemical extinguishers of the truck; in opening roofs, floors, partitions; in wrecking, and such other duties as may be necessary.

Chemical Engine Company. — This company should consist of six men, including a captain and lieutenant. Two men should have charge of operating the engine tank, and of opening and closing the main tank valve, in addition to agitating and mixing the chemical charge, and of recharging. The men should be familiar with the operation of the engine. Two men should be selected to carry and direct the nozzle, and assist in handling the line of hose.

Standpipe Company. — Where the plant is equipped with an interior standpipe system, a company should be organized, consisting of at least four men to each hose line, with a captain and lieutenant. Each hose line should have a valve man and two pipe men. The valve men should turn the water on and off, and assist in unreeling the hose. The pipe men should handle the play pipe and assist in unreeling and laying of hose.

Fire Pails and Chemical Extinguishers. — A special detachment of men should be delegated to handle chemical extinguishers, fire pails and other equipment.

Pumps. — Where pumps are used in the fire service, the engineer, and his assistants, should be made members

of the brigade. They should remain on duty, operate the pumps, and see that sufficient steam pressure is maintained to give efficient service.

Salvage Corps. — Several trustworthy employees, under the direction of a captain and lieutenant, should be appointed to assist in the recovering of valuable books, stock, fixtures or other material, and to prevent water damage, where possible. They should be provided with rubber blankets and other equipment, which they can use to advantage at the time.

Drills. — Fire drills should be held at least once a month, and should have two main objects: first, promptness in reaching the point of fire by designated routes; second, practice in handling all fire apparatus and appliances. Alarms should be sounded at times previously unknown to employees. The drill should be carried out as if there were an actual fire in a certain building.

The location of the objective point should be changed with each drill, in order that employees may get a thorough knowledge of the interior and location of fire apparatus in every building in the plant.

CHAPTER VII

BOILERS

Types. — There are many types and combinations of boilers, all of which have certain advantages in the particular uses to which they are adapted. They may be of the stationary, locomotive, marine, portable and semi-portable; horizontal or vertical; internally or externally fired; shell, sectional, water-tube, and fire-tube types. There are also different kinds of coal-burning, gas-burning, and oil-burning boilers. All of these features give rise to many different forms and a great variety of construction.

Strength of Boilers. — The strength of a riveted joint is always less than that of the solid plate because some of the plate is cut away for the rivets. The efficiency of a riveted joint is the ratio of the strength of the joint to the strength of the solid plate. The tensile strength of the metal between the rivet holes should be in general about equal to the shearing strength of the rivets. It must be remembered that a boiler can be no stronger than its weakest joint. The design of joints and other details should be placed in the hands of an expert.

Boiler plate may be manufactured of wrought iron or mild steel. At the present time nearly all boiler plates are made of steel, manufactured by the open-hearth process. The tensile strength should be from 55,000 to 65,000 lbs. per sq. in. Test pieces should be subjected to the various tests called for in the specifications, such as tensile and elongation tests, bending tests, homogeniety tests, tests for yield point and chemical analysis. The purchaser should insist on standard specifications.

A representative of the purchaser should be allowed to witness all tests called for in the specifications at the place of manufacture, prior to shipment, in order to satisfy himself that the material is furnished in accordance with the specifications.

Factor of Safety. — If a boiler is well designed and carefully made, a factor of safety of four on the strength should suffice when the boiler is new. This factor should allow for a reasonable amount of corrosion and wear. However, a factor of safety of five and even six is not infrequently used. A higher factor than four should be used where there remains any doubt as to the strength of the boiler, depending of course upon the existing conditions.

Cast Iron. — Cast iron is particularly susceptible to flaws, due to unequal cooling in the moulds. It is, therefore, an unsuitable material to withstand high steam pressures. It is also too brittle a material for safe use. Fittings, manholes, handholes, flanges, pipes, and other boiler accessories should not be made of cast iron. Malleable iron or cast steel should be used instead.

Joints. — Lap joints are undesirable in the construction of a boiler for the reason that serious bending stresses are produced by contraction and expansion of the metal under changes of temperature. Thus a crack may develop under and along the rows of rivets, which will remain undetected, unless the rivets are cut and the plates parted for an examination.

Butt joints are far preferable and should be exclusively used. With this construction, the plates form a true arc of a circle at the joint. They are, therefore, not subjected to the bending action above described. The butt joint also has a much higher efficiency of strength, which is important with high steam pressures now in general use.

The circular seams of horizontal tubular boilers should lap away from the fire. Horizontal seams should be on the upper half of the boiler when set, and not exposed to the direct flames of the fire.

Rivet Holes. — All rivet holes should be drilled with the sheets bolted in place. The plates should then be moved apart, and the burr on the edge of the holes removed. Where it becomes necessary to punch holes in plates, they should be punched at least one-fourth of an inch smaller than the diameter of the rivets. The holes should then be increased to full size by means of a reamer. Holes should never be punched full size. Tapered drift pins should not be used to enlarge holes. This would strain and weaken the plate near the holes.

Patches. — Patches should not be resorted to in case part of a plate becomes burned, cracked or corroded. The whole sheet should be replaced.

Setting Tubes. — Tubes of water-tube boilers should be rolled and belled. Tubes of fire-tube boilers should be rolled and beaded. Holes for tubes should be drilled and chamfered. Expanding of tubes should be carefully done by an experienced workman. Where the tubes are beaded, there is little opportunity for soot, which induces corrosion, to collect at the ends of the tubes. The staying power of the tubes is also thus increased.

Staying. — Many different methods of staying for different types of boilers are used. The placing of stays and arrangement of details are an important part of boiler design, and should be worked out by an experienced designer for each individual type of boiler. All plates, that are not cylindrical or hemispherical in shape, require staying, in order that they may hold their shape. The staying of flat plates is accomplished by symmetrically arranging a number of supports for fastening stays. This will evenly hold the plate against pressure.

Manholes. — The manhole should be large enough to easily admit an average size man into the boiler. An elliptical manhole opening should not be less than 11″ × 15″ or 10″ × 16″ in size. A circular manhole opening should not be less than 15″ in diameter. The ring should be strong enough to compensate for the plate which is cut

out. Manhole plates should be of cast or wrought steel. Cast iron should not be used. The manhole cover should be so placed inside the ring that it will be held to its seat by steam-pressure, being drawn up to its seat by a bolt and removable yolk. Horizontal tubular boilers should have two manholes to facilitate proper inspection and cleaning; one above the tubes in the shell, and one below the tubes in the front head. The manhole in the shell should be cut with the long diameter girthwise.

Handholes. — Handholes for aiding in washing out and cleaning should be provided at different parts of the boiler. In the case of horizontal tubular boilers, if there is a manhole under the tubes in the front head, there is no need of a handhole in the rear head. Where there is no manhole in the front head, handholes should be placed under the tubes at both the front and rear heads.

Settings and Supports. — Boiler supports should, in all cases, be made of structural steel, where the boiler is not self-supporting on the foundation. The supports of water-tube boilers should, so far as the movements of either the boiler or setting due to heating are concerned, be independent of the brickwork of the setting.

Where two horizontal water-tube boilers are set together in one battery, continuous girders, from which the boilers are to be suspended, should be run over the boilers from one side of the battery to the other. These girders should be strong enough to safely support the boilers without the aid of vertical columns set in the division walls of the boilers. Cast iron brackets on boiler shells should never be used.

Boiler fronts should always be bolted to the settings in such a way that they will not become loose when the brickwork is removed.

In the case of gas-fired boilers, one or more explosion doors should be fitted into the wall of the setting, communicating with the last pass. The seats of these doors should be set at an angle by means of which gravity closure is

obtainable. At the same time, they should be free to open in case excessive pressure is developed in the setting.

It is particularly important, in the case of boilers which have large bottom drums, such as those of the Stirling type, to keep the brickwork around the windows at the ends of the drums entirely free from contact with the metal surface. These windows should be closed by means of a separate tight-fitting cast iron door, attached to a circular casing, which is properly fitted to the brickwork.

Water Columns. — Each boiler should be equipped with a water column and fittings, so located that a clear view of the gauge glass from the boiler room floor will not be intercepted by a stairway, platform, or any other object.

Water columns should be of an approved design, each fitted with three try cocks of the lever type. These should be connected by chains or rods to handles which are readily accessible from the boiler room floor and operating platform. No valves should be permitted between the water column and the boiler. The pipe from the water column to the boiler should be connected by means of steel flanges riveted to the shell. Tapped connections should not be used for the support of water columns. Crosses and plugs, which will give ready access for internal cleaning of the water column, should be used in the steam and water connections. Ells should not be used.

Water columns of horizontal tubular boilers should be so set that the difference of level between the bottom try cock, and the level of the top row of tubes, will be at least 3 inches. Gauge glasses should be so set that the lowest visible level of the water will correspond to a $1\frac{1}{2}$ inch water level over the tubes. Drain connections from the water column should have an open end to the ash pit. There should be a receiver of sufficient size at the bottom of the water column in which sediment may collect and be blown out. Metallic unions should be used, obviating the use of soft packing material. Pipe connections, leading to the water column, should be covered.

Special annealed glass should be used for the water column. Glass above the water level is subject to the chemical action of condensing steam. In the course of time, the glass will become worn. It is then likely to burst from the high pressure of the steam. As the glass is very brittle, it will explode into countless fragments. These may be lodged in the eyes of attendants, unless the glass is properly guarded. Many eyes have been lost through the bursting of boiler gauge glasses. The glass should be provided with a suitable guard, which will protect the eyes of attendants, in case the glass bursts. Fig. 12 shows an excellent type of wire-glass guard. This forms an integral part of the water column. It must be in position before the joints around the tubular glass can be made. The wire-glass is of special quality, affording ample protection from all shocks and stresses and flying particles of broken glass, in case the tube bursts. Steam, water, and fragments of glass must escape through a tortuous passage around a vertical baffle plate into ample back space. The steam is then allowed to escape through a fine wire-mesh screen, while the discharge port at the bottom releases the flow of water, safely carrying some of the broken fragments of glass to the deck. The wire-glass guard enables the attendant to obtain a clear view of the water level at all times. It also allows a safe approach for closing the valves in case the tubular glass bursts. Swivel metal guards are also used, but they do not offer as good protection. In case the gauge glass bursts, the water valve should be closed first.

FIG. 12
Wire-glass watergauge guard.
Courtesy Sargent Company, Chicago.

The water column connections are apt to become clogged from sediment or incrustation, holding water in the tube when there is insufficient water in the boiler. Thus a false indication of the water level may be shown. For this reason, reliance should not be placed on the water level shown in the gauge glass, but the gauge cocks should be frequently tested. Steam, which escapes from the upper cock when opened, becomes superheated as it blows into the atmosphere, showing a bluish color. When the lower cock is opened, hot water should be discharged. This will flash into steam as it escapes, but has a whitish appearance in contrast to this bluish color of the steam which escapes from the upper cock.

When either cock of the water column is closed, the water level in the glass tube will rise. When the upper cock is closed, the steam in the upper part of the tube will gradually be condensed by radiation, and replaced by water. When the lower valve is closed, the steam in the tube will be partly condensed, causing the water level to rise.

When cleaning a tube, a wire should never be forced through. This might scratch the glass. The slightest scratch will cause it to gradually weaken at this point. This may later cause the tube to explode. The glass tube may be cleaned, when in place, by closing the lower cock and opening the drain cock, blowing steam through. Tubes should not be allowed to become dirty. When they become so stained that a clear view of the water level cannot be obtained, they should be replaced with new ones.

Each water gauge glass should be especially well lighted.

High and Low Water Alarms. — High and low water alarms are not recommended, as they are unnecessary, and tend to encourage carelessness among attendants.

Fusible Plugs. — In case the plate is in danger of becoming overheated, the fusible metal in the plugs, which are screwed into the plate at various points, will melt and flow out, allowing the steam and water to blow into

the furnace. This will put out or check the fire, calling the attention of the attendant. Plugs should be kept clean, otherwise they will not act. They should also be replaced with new ones at least once a year, as the melting point tends to rise under continued heat. The plug should be conical in shape, so that it cannot be blown out by the steam pressure. If the plugs and plate are allowed to become covered with scale, the metal may melt and run out without giving any warning. In general, fusible plugs should be placed at the lowest permissible water level, in the direct path of the products of combustion, and as near the primary combustion chamber as possible.

Steam Gauges. — Each boiler should be provided with an individual steam gauge, directly attached to the boiler by means of a syphon of sufficient capacity to insure the gauge tube being kept full of water. No valve, other than the gauge cock, should be allowed between the gauge and the boiler.

At least one recording gauge should be connected to each steam system, so that, in case an accident occurs, there will always be an available record of the steam pressure at that time.

Steam gauges should be carefully adjusted and frequently tested to insure correct readings. When the safety valve is blowing off, the pressure indicated by the steam gauge should be observed. If this does not agree with the pressure at which the safety valve is set to blow off, the trouble should be located and corrected. If steam gauges on boilers, which are being cut in, register incorrectly, unequal pressures between the boilers will be likely to cause an explosion.

Safety Valves. — At least two, spring-loaded, pop safety valves should be installed on each boiler. These should be directly connected by separate steam nozzles, having no communication with any other part of the steam system. Under no circumstances should a valve or any other fitting be allowed between the safety valve and the boiler,

nor in the escape pipe. The casing surrounding the safety valve spring should be so locked that only authorized persons can obtain access to the spring for inspection and adjustment. A testing lever should project through the casing, so that the valve may be lifted from its seat at the time of its periodical inspection.

Each safety valve should be of sufficient capacity to discharge all the steam that the boiler will produce when it is evaporating at its normal capacity. The escape pipe should not be less in internal diameter than the valve.

Existing rules and statutes governing safety valves are not safe to follow. They assume that valves of the same nominal size have the same relieving capacity, and they rate them the same without distinction, in spite of the fact that in actual practice some of them have but one-third the capacity of others. These rules also assume that the lift varies as the valve diameter, while in reality the lift does not vary nearly as rapidly as the diameter. Moreover, the lifts assumed for the larger valves are nearly double the actual average obtained in practice. Thus different makes of safety valves, which actually vary in lift and relieving capacity over 300 per cent, are rated exactly alike. It is therefore the duty of all who are responsible for steam installation and operation to leave the determination of safety valve size and selection no longer to such rules and statutes as may exist in their territory, but to investigate for themselves.

The springs of safety valves become gradually weaker with use. In order that a weakened spring may continue to resist the pressure, it must be further compressed. This reduces the pitch of the spring and the lift of the valve. Therefore, a record should be kept of the lift of the valve, and its rated capacity. All valves should be examined at least once a year, to make sure that the original lift is approximately maintained.

Escape pipes should be vertical, having an outlet through the roof of the boiler house wherever practicable.

Horizontal escape pipes should be avoided in all cases, as they produce severe thrusts on the boiler nozzles when a violent escape of steam occurs. Drain pipes, opening to ash pits, should be placed on escape pipes, as near the safety valves as possible.

Wherever lever safety valves are used, the weights should be locked in the proper position, thus preventing them from being moved by an unauthorized person. The safety valve should never be overweighted or wedged down, preventing the boiler from blowing off steam. This practice is likely to result in an explosion.

Safety valves should be properly adjusted and receive constant care. They should be tested at least twice a day by lifting them gently off their seats. This will insure freedom of operation. Safety valves should also be frequently tested by comparing the pressure at which they are set to blow off with the pressure indicated by the steam gauges. The adjustment of safety valves should be performed by an experienced engineer. A safety valve should be adjusted by means of two steam gauges, instead of one, to obtain a careful check on the work.

Stop and Automatic Cut-off Valves. — Stop valves, as well as any valves on a high pressure line, should be opened and closed gradually. If provided with a by-pass, the latter should be used for the admission of steam before the main valve is opened. Valves should be placed in such a position that no pocket can be formed in which water might collect. Where two or more boilers are connected to a common header, there should be an automatic cut-off valve in addition to the main stop valve. The automatic cut-off valve should be placed between the main stop valve and the nozzle of the boiler, as near the nozzle as possible. The valve should be of the triple-acting type, protecting the line as well as the boiler. This type of valve will close automatically if any part of the boiler gives way, thus preventing the steam from the other boilers entering the disabled boiler; or, it will close in

case a steam pipe bursts or a header blows out. It will prevent an accident caused by opening a valve too quickly, also preventing steam from entering the boiler when a man is inside. The automatic cut-off valve should be provided with a lever, indicating whether the valve is open or closed.

Feed Water Connections.—There should be two independent means of feeding water to a boiler. In case one system fails, the other may be used. The feed pipe should be equipped with a stop valve and a check valve placed near the boiler. The stop valve should be placed between the check valve and the boiler. There should also be a stop valve between the main feed line, if the boiler is one of a battery, or near the feed pump, in case of an isolated boiler. A drain pipe should be provided between the valve at the main feed line and the stop valve at the boiler. This will prevent the accumulation of water pressure, in case the former valve should leak when the boiler is out of service.

The feed pipe should deliver water considerably below the lowest water level of the boiler. The feed water should be discharged in such a place in the shell that it will not come in immediate contact with the plates which are exposed to a high temperature. Cold water should never be fed to a boiler. It would cause parts to weaken under large variations of temperature. Feed water should be preheated by means of a feed water heater. The feed pipe should be equipped with a feed regulating valve. Wherever feed water regulators are used, they should be accompanied by governors placed on the boiler feed pumps.

Feed Pumps. — Each boiler plant, consisting of more than one boiler, should be equipped with feed pumps in duplicate. If direct acting pumps are used, they should be of the outside packed plunger type. For a single boiler the feeding system may consist of one steam pump and one steam injector, or of two steam injectors.

Feed pumps should be so located with reference to the lowest level of water in feed water heaters, that there will

be a sufficient head on the inlet valves of pumps, at all times, to overcome the frictional resistance of the valves, to provide the necessary velocity of flow to the pump, and to overcome the vapor pressure due to the temperature of the feed water in the pump chambers. Valves for feed pumps should be of the metallic, hard rubber, or fiber type, capable of withstanding disintegration under the high temperatures which exist.

Where economizers are used, the feed pipe system should be provided with a relief valve, protecting economizers and feed piping from excessive pressure and shocks.

Feed pumps should be equipped with governors which will maintain a constant excess pressure in the feed pipe above the boiler steam pressure.

Feed Water Heaters. — Some type of a feed water heater should be used in connection with boilers, as the admission of cold feed water causes excessive contraction, which strains the boiler and causes weakness.

In the open type of feed water heater, the exhaust steam from the engine and pumps mingles with and heats the feed water in the feed water heater to the proper temperature before entering the boiler. Exhaust steam from the engine and pumps should never be allowed to find its way back to the boiler, therefore the open type of feed water heater should not be used.

Closed feed water heaters prevent the exhaust steam, used for heating, from mingling with the feed water, the exhaust steam being kept separate by means of coils or pipes through which it passes; or, the feed water may pass through water tubes with the exhaust steam on the outside of the tubes in a steam chamber. This prevents oil from getting into the feed water. In the latter case, however, there is no provision for removing the scale from the heater. Oil will collect on the steam side of the tubes and scale on the water side. The scale is not easily removed. This is a disadvantage for this type of heater.

A combined live steam purifier and heater is the best device for heating the water, rendering it pure. This is in effect an open feed water heater, through which live steam, direct from the boiler, is passed. This preheats the feed water before it enters the boiler. It must be strongly built to withstand the steam pressure. It should be provided with a safety valve, to relieve the pressure should it become too high; also, with an air vent to release the air, which is contained in the feed water. No provision need be made for oil removal, as the steam for heating the feed water comes directly from the boiler. In this case, the action is the same as that of an open feed water heater, except that the feed water is raised to a higher temperature before it enters the boiler.

Open feed water heaters should be provided with an automatic overflow valve, so there will be no danger of the water level rising above the exhaust opening, flooding the engine.

Steam Mains and Connections. — Steam headers, receiving steam from several boilers, should be placed at a sufficient distance from the nozzles of the boilers to permit the use of "goose-neck" connections, capable of considerable expansion without introducing dangerous stresses on flanges and nozzles. A straight connection from the nozzle to the header should be avoided. A bottom connection to the header should not be used. Where a line is reduced from one size to another, eccentric fittings should be employed. These will bring the bottom of the different size pipes to the same grade line, thus avoiding pockets.

Pressed or rolled steel flanges should be exclusively used. Cast iron flanges should not be permitted. Sections of pipe should not be bolted in place until the companion faces of the flanges are machined to true parallel planes. Flanges should match properly without the necessity of springing the pipe into place. If they do not fit properly, the section should be fitted to a prepared template, making the necessary alterations.

A gate stop valve of approved construction should be set in the "goose-neck" connection, as near the steam header as possible. In all cases, the threads of the valve stem should be outside the valve casing. A non-return valve of the triple-acting type should be set in the "goose-neck" connection as near the nozzle as practicable. The valve should be provided with an effective cushioning device, preventing hammering and destruction of the seat, when the pressure on each side of the valve is nearly equal.

Drain pipes, preventing the formation of water pockets when the valves are shut, should be placed in the "goose-neck" connection, one just above the stop valve, and one just above the non-return valve. These drain pipes should lead to traps which will automatically remove water that may collect. The outlets from these drain pipes should be so placed in the traps that water cannot return through these pipes. A check valve should be set in each drain pipe, preventing the backward flow of steam when the boiler is cut out of service.

Baffle Plates.—A baffle plate should be placed in the drum under the steam nozzle of each boiler. It should be attached by angle irons, riveted to the interior of the steam drum or boiler shell. This baffle plate should extend about 3 feet from each side of the steam nozzle, being located about 8 inches below the top of the shell.

These baffle plates serve to take the moisture out of the steam before it enters the pipe system. Steam, on its way to the nozzle, passes around the ends of the baffle plate. The plate is perforated with small holes for the discharge of water which collects from the steam before it enters the nozzle. Dry pipes may also be used in lieu of baffle plates.

Steam separators are also useful in separating water from the steam just before it enters the engine. It is important to furnish the engine with dry steam. Wet steam is injurious and less efficient.

Domes should not be placed on boilers. If extra steam space is required, a steam drum should be used. The use of a dome weakens the boiler.

Superheaters. — Superheaters are useful in obtaining dry steam. They also increase the energy in steam above that which it possesses when only saturated. Steam which is too highly superheated, however, is likely to warp the ordinary slide and Corliss valves. Too high a temperature also causes some difficulty in the lubrication of the piston and valve rods. A steam temperature of 500 degrees F. corresponds to about 130 degrees of superheat at 150 pounds pressure. This amount of superheat insures dry steam in the ordinary forms of engines.

Blow-off Connections. — When the blow-off branch pipes are so located as to be exposed to the hot products of combustion, they should be protected by fire-brick piers. A sufficient space should be provided for the inspection of all parts of the blow-off connection. No part of the connection should be allowed to come in contact with brickwork or flue dust. Blow-off valves should be attached in pairs to each blow-off pipe. The valve next to the boiler should be a gate valve. The valve connecting the branch to the main blow-off line should be a regular boiler blow-off valve. A short drain pipe should be placed in the connection between these two valves.

Blow-off headers should be laid in concrete trenches, with "Y" connections to the branches. Steel pipe should be used. This should be free to expand, preventing excessive strain when it becomes heated. Blow-off headers should discharge into a hot well. This well should be provided with a pipe at least 10 feet high for the escape of vapor. No reducers should be allowed in the blow-off line.

Blow-off connections should be frequently and carefully inspected for leaks. If a leak is discovered, it should be remedied at once.

Blowing Down Boilers. — Attendants should blow down

each boiler two or three inches at least twice a day, preferably when coming on duty in the morning and again before starting up in the afternoon. If blown down at these stated times, the sediment and scale forming material will have had time to settle on the bottom. It may then be easily blown out before having a chance to harden on the plates. Before blowing down, the gauge cocks should be tested, and the water level observed in the glass tube. Care should be taken not to blow down the boiler too long, causing the water to descend below the safe level. For this reason, an assistant should observe the water gauge when the boiler is being blown down. The blow-off valve should be opened slowly to avoid waterhammer.

Surface Blow-off. — The surface blow-off should be used several times a day to remove accumulations which collect on the surface of the water in the boiler, thus preventing this material from finally settling and forming scale on the plates.

Waterhammer. — Waterhammer is caused by the hammering of a body of water against a pipe or fitting. This may be violent enough to cause disruption. The rapid movement of the body of water is occasioned by the condensation of steam, causing a partial vacuum, with the consequent phenomenon of waterhammer. Condensation of steam will always take place if a comparatively cold surface of the water is exposed to it. Waterhammer is one of the direct causes of explosions, and is attributed to the following causes:

1. Introducing water, or the condensation of steam, in steam pipes.
2. Inadequate draining of steam pipes.
3. Admission of steam to pipes containing water.
4. Introducing steam under a column of water.
5. Presence of steam and water on both sides of a valve, i.e., opening a valve with unequal steam pressure on each side, and water on at least one side.
6. Sudden arrest of a moving plug of water, i.e., vacuum on one side, or steam or air in front of the advancing plug — the steam or air escaping through a small orifice, whereas, the water plug is suddenly checked.
7. Damming up of water in unused portions of long and complicated pipelines.

Explosions of Steam Pipes.—The causes of explosions of steam pipes are due to the following:

1. Waterhammer.
2. Vibration — too great rigidity of the steam pipes.
3. No provision for expansion and contraction of steam pipes.
4. Lack of support of steam pipes.
5. Defective steam pipe joints.
6. Lack of ductility in steam pipes.

Explosions of Boilers. — Explosions of boilers can only be guarded against by frequent and expert inspection, proper installation, and careful operation by experienced attendants.

Boiler explosions are chiefly due to the following causes:

1. Defective material.
2. Weakness.
3. Abnormal steam pressure.
4. Defective design.
5. Corrosion (internal and external).
6. Faulty construction.
7. Overheating.
8. Faulty repairs.
9. Scale formation.
10. Waterhammer.
11. Defective joints.
12. Failure of safety devices to act properly.
13. Careless and improper operation.
14. Rendering safety devices inoperative.
15. Lack of safety appliances or accessories.
16. Lack of frequent and expert inspection.

Impurities in Feed Water. — Practically all waters, available for boiler feed, contain impurities. The effects of these impurities vary considerably, but they are all injurious. Impurities cause either corrosion or incrustation, or both. The impurities may be either held in suspension or in solution. They may be subjected to both chemical and mechanical action.

The common impurities encountered are: Calcium Carbonate, $CaCO_3$; Magnesium Carbonate, $MgCO_3$; Calcium Sulphate, $CaSO_4$; and Magnesium Sulphate, $MgSO_4$. Impurities which are less frequently found in smaller quanti-

ties are: Calcium Chloride, $CaCl_2$; Magnesium Chloride, $MgCl_2$; Sodium Chloride, NaCl; Potassium Chloride, KCl; Iron Carbonate, $FeCO_3$; and small amounts of Calcium Phosphate, silica, iron oxides, and organic matter.

Corrosion. — Corrosion, the most frequent cause of boiler explosions, may be either internal or external. Internal corrosion is due to acids and air contained in the feed water. Pure water, free from air and acids, has little or no effect on wrought iron or steel, and only a superficial effect on cast iron. Acids find their way into the boiler by a contaminated supply of water, or by the entrance of adulterated cylinder oil. Waters may contain decaying vegetable matter, certain salts, chemicals, sulphuric acid from mine waters or ore containing sulphur, mud in suspension, and oils which attack the iron. Carbonic acid is always contained in feed water. The chemical action, which it sets up, liberates more acid, resulting in an accumulative effect. Ordinary scale forming material, — lime carbonate and lime sulphate, — has little direct corrosive action, unless the scale becomes too thick. A slight coating of these salts acts as a protection against corrosion. The chlorides of lime, sodium, and magnesium, however, aid corrosion.

Galvanic action may also take place, if copper or some other metal is present, resulting in corrosion. Galvanic action may also be caused by the lack of homogeneity in the metal of a boiler, the action taking place between the particles of metal of different potential, thereby producing an infinite number of galvanic cells. Carbon, copper, and brass are all electro-positive to iron and, when in contact with it, cause disintegration. Zinc, tin, and lead are electro-negative to iron and, when in contact with it, tend to preserve it. Galvanic action may thus be stopped by placing pieces of zinc in various parts of the boiler.

Oxygen is essential to corrosion. In combination with any acid in the water, or carbonic acid in the air, it causes a process of rusting which yields more carbonic acid, thus

accelerating disintegration. This action produces patches below, or just above, the water line, which is called "pitting." Poor circulation of water increases the action. This takes place most rapidly where the water is least active, or where strains loosen the rust, exposing more metal to the air. Air bubbles, which are given up when the water comes in contact with the hot plates, if the circulation be poor, may remain in contact with the plate where they cannot rise after once being formed. If the air is not allowed to escape, they may also collect between the water and the steam. Pitting may be prevented by entirely expelling the air before the water enters the boiler, using distilled or condensed feed water containing little or no air, and a feed pump which introduces no air into the boiler.

Animal and vegetable oils are composed of fats which break up into acids and bases, leaving the acids free to attack the iron. Mineral oils, on the other hand, will not corrode iron.

The internal surface of a boiler should be smooth and even, and free from scratches. If scratches or indentations are present, they form points which become the center of corrosion and pitting.

Grooving is usually due to the springing or buckling of the plate, which, in turn, is caused by insufficient staying or defective fastenings. This causes the plate to bend back and forth with increase or decrease of pressure. Strains and weakness are thus produced. Minute cracks are often thus formed which are difficult to detect. These places are favorable to corrosion, which forms grooves in the metal. This bending effect may also loosen scale at these points, which would otherwise serve as a protection, if not too thick, exposing this part of the boiler to corrosive action. Too great rigidity is another cause of grooving which must be guarded against.

It is advisable to have an analysis made of the feed water before using it for the boiler. Analyses should be

made from time to time, if the water is known to contain impurities. River waters change in composition at different periods, especially in times of drought. An analysis will determine the prescription to be applied to the water in any particular instance.

General corrosion acts over large surfaces and is difficult to detect. In this case the material wastes away evenly, causing a thinning of the plates. Where boilers have been in use for some time, it is advisable to test the thickness of the plates by drilling. If the plates have been thinned by general corrosion, the working pressure should be reduced.

Boilers in operation will not corrode externally to any extent, if the free air and fumes are entirely dry. Leaks from seams, joints, and patches will result in quite rapid corrosion, due to moisture with free air and acid fumes. In this case, the plates will be eaten away very quickly. Corrosion from leakage may be hidden by scale, being only detected by a thorough examination. Longitudinal joints should be kept free from the brickwork, and the blow-off pipe protected from contact with the brickwork. Damp brickwork causes rapid corrosion to take place. All brickwork in contact with the boiler should be of fire-clay brick. Common brick should never be in contact with the metal, as water may percolate through it, damaging the boiler. Drippings on a boiler, if laden with sulphur fumes, will quickly attack the iron.

Fire tubes are subject to rapid corrosion, if the coal or coke contains much sulphur. Ashes and cinders are carried through the tubes at a high velocity when the draught is forced by a blower. This will cause erosion of the tubes. When tubes are inspected, they should be probed to detect pitting or wasting. The tubes should be regularly drawn and subjected to a hydraulic test.

Fires should never be damped with moist ashes, as the sulphur which they contain will form sulphuric acid, which will attack the iron.

Scale Incrustation. — In the course of time a deposit or incrustation of scale will be formed on the plates within the boiler and within the tubes. This scale is an extremely poor conductor of heat. It prevents a large amount of useful heat from being transmitted to the water within the boiler. The scale withholds the heat, causing over-heating or burning of the plates or tubes. This weakens them, causing them to bag, rupture, or crack. Tubes will also become loose at the joints, resulting in leaks.

It is important to prevent the formation of scale by taking the necessary precautions. Scale formation is one of the principal causes of boiler explosions. It also greatly reduces the power and efficiency of a boiler. Scale $\frac{1}{50}''$ thick requires an additional 5% fuel; scale $\frac{1}{16}''$ thick, 15%; scale $\frac{1}{8}''$ thick, 30%; scale $\frac{1}{4}''$ thick, 68%; and scale $\frac{1}{2}''$ thick, 150%.

Chemicals should be introduced into the boiler to soften the scale, so that it may be removed in washing; otherwise, if this does not suffice, the scale should be removed by mechanical means. Sodium hydroxide (NaOH), in the proportion of 1 pound to 60 gallons of water, is most commonly used, about 40 pounds being required per 100 B.H.P. This solution should be allowed to remain in the boiler, over a low fire, for at least two days. The boiler should then be cooled and blown down. The interior should then be cleaned and scraped of all scale. If the scale is not immediately removed after the boiler is emptied of water, it will again harden on exposure to air.

Sodium hydroxide is dangerous if not properly handled. It should never be allowed to come in contact with the hands, eyes, or other parts of the body. It is a very strong caustic and will cause serious burns. A bottle, containing a solution of sodium bicarbonate, should be kept on hand in the boiler room for an emergency. If sodium hydroxide should accidentally come in contact with the eyes or hands, the solution of sodium bicarbonate should be immediately

applied. This solution will counteract the injurious effects of sodium hydroxide.

Tannic and acetic acids break up the carbonates which form scale, but have no effect on the sulphates. These acids also attack iron. Therefore, it is best not to use them, but resort to the proper chipping and scaling tools. Crude petroleum should not be used, as it may contain sulphuric acid, which attacks iron.

The tubes of water-tube boilers are especially susceptible to the formation of scale. They require special attention. The blow-off pipes, water column connections, and feed pipes should be kept free from scale. They should be frequently examined to see that the aperture is not being closed or clogged by incrustation. Organic matter may often be removed by using the surface blow-off several times a day.

Refined kerosene oil softens scale, having no injurious effects if free from acids. The boiler should be filled with water, and 2 gallons of kerosene poured in. The oil will remain on top. The water should then be gradually drawn off. The kerosene will thus be spread over the sides, attacking the scale. The boiler should be thoroughly ventilated after kerosene has been used, to remove all kerosene vapor.

The prevention of scale requires a knowledge of the chemistry of the feed water. Analyses should be made periodically, and the proper treatment applied. Many scale-forming impurities may thus be removed before they enter the boiler, or they may be precipitated and removed, before they have a chance to cement on the plates and tubes, by periodically blowing off the boiler.

Prepared boiler compounds, which are offered for sale, should not be used unless it is positively known of what they consist, and whether they are applicable to the feed water in question.

Carbonates.— Feed water containing calcium and magnesium carbonates deposits the oxides of calcium and

magnesium when the carbonic acid is driven off by boiling. If the feed water is previously heated to a temperature of 212° F., remaining at that temperature some time for the carbonates to settle before it enters the boiler, the carbonates will be mostly deposited in the feed water heater. Calcium and magnesium carbonates are soluble in water containing some carbonic acid, but when heated, the carbonates return to the insoluble form and are then deposited. These carbonates form a porous deposit, which does not alone readily adhere to the metal, but often some other substance is present, which mixes with the deposit, forming a hard scale. Magnesium hydrate may form from the carbonate, however, and cement it to form scale. Carbonate scales are not usually hard to remove.

Sulphates. — Calcium and magnesium sulphates are dangerous, forming an extremely hard scale which is very difficult to remove. These sulphates are deposited at a temperature of about 300 degrees F. Since they remain soluble up to about 300 degrees F., they are not so easily removed, as are the carbonates, before the feed water enters the boiler. These sulphates also act as a cement for mud and other material.

These substances may be removed in an open feed water heater by the addition of certain chemical compounds. The common substance used is sodium carbonate (soda ash, black ash, or sal-soda). Above 200 degrees F. this substance reacts chemically with the sulphates (including sodium sulphate) to form the carbonates of calcium and magnesium. These carbonates are then deposited at this temperature before the water enters the boiler, except the sodium carbonate, which is soluble, passing into the boiler where it remains until the solution is saturated, when it is then precipitated. Before it can be deposited, however, it passes off through the blow-off.

Inasmuch as the sodium carbonate passes off to some extent through the blow-off, it becomes necessary to intro-

duce it frequently in small quantities into the boiler. It is a mistake to believe that a large charge will serve the purpose for a comparatively long period. The carbonate will soon have all passed off in the blow-off, there being none left to prevent scale from forming.

Sodium carbonate also neutralizes any acids which may be present, preventing them from attacking the iron. The acidity of the water may be tested by blue litmus paper. If acid is present, the paper will turn a reddish tint. If the water contains acid, the alkali should be added until the paper returns to the bluish tint again. A small amount of caustic soda, added to the carbonate, is also useful.

When filling a boiler with fresh water, it is advisable to add a few pounds of sodium carbonate. Afterwards, the addition of three or four pounds a week should be sufficient, but the exact amount must be determined by a chemical analysis of the feed water. A large quantity should never be used, as it is only wasteful and harmful. If the water contains a large amount of dissolved salts, the sodium carbonate is not effective. The impurities should be removed before they enter the boiler, otherwise the supply should be abandoned.

Before entering the boiler, the sodium carbonate should first be dissolved in water. It may be introduced by means of a small tank connected with the suction of the feed pump. Care should be taken not to admit any air to the pump. Sodium carbonate may also be thrown into the feed water tank or reservoir, reaching the boiler in this way.

Chlorides.—Magnesium chloride has cementing properties which render it troublesome. It may react with the water to form magnesium hydrate and hydrochloric acid, which attacks the metal. The other chlorides encountered, namely sodium and potassium, are not especially harmful, unless the solution becomes saturated, after which they may be deposited. They may, however, cause the water to foam, especially if present in considerable quantities.

Mud. — If mud is not blown off, it will collect upon the plates or tubes, becoming baked on the heating surface. Mud should be entirely removed by filtering, or by means of settling tanks, before the water is allowed to enter the boiler. These tanks should be cleaned at regular periods.

Circulation of Water. — The free and constant circulation of water in a boiler is of the utmost importance. Heat is transmitted very rapidly through the tubes and shell of a boiler. If the circulation is poor or lacking, a film of steam will collect on the tubes and plates, causing them to burn. Steam is a very poor conductor of heat. For this reason, the heat cannot be transmitted directly to the water fast enough to avoid burning the metal. If the water flows freely along a boiler tube, it is impossible to burn the tube, even with the most intense heat. Good circulation will prevent air from forming on the surface of the water, which otherwise would cause rapid corrosion. Tubes should not be staggered either vertically or horizontally, as they would thus interfere with the proper circulation of the water. Boilers should be so designed that a free and rapid circulation of water will be possible.

Foaming. — When the steam space in a boiler is partially filled with bubbles of steam, the phenomenon is called foaming. This may be caused by too much sodium carbonate, or by other substances which may be either dissolved or suspended in the water and which interfere with the free escape of the steam from the surface of the water. Oil, sewage, or vegetable matter may form a scum through which the steam bubbles find difficulty in breaking. Suds may be formed if an alkali is present which acts upon the oil to form a soap. Oil frequently enters the boiler from the condenser, where it finds its way from the cylinders of the engine or pumps. Oil should be prevented from returning to the boiler by means of effective oil separators or extractors. Large quantities

of salts in the water within the boiler may precipitate as the solution becomes saturated, causing foaming and priming.

Cleaning. — Although every precaution be taken, it is practically impossible to entirely eliminate the formation of scale. Therefore, it becomes necessary to occasionally clean this incrustation from the boiler and tubes. Soot also collects on the outside of boilers, and on one side of the tubes. Water tubes are cleaned by water-turbine tube cleaners with rotary cutters. As the scale is cut, it is washed out of the tube by the water. Fire tubes are cleaned by compressed air power cleaners, hammering the inside. The vibrations dislodge the scale, and the soot is cleaned by rotary brushes and scrapers. Steam power cleaners should not be used in fire tubes, unless the tubes are hot, otherwise, the steam would cause the soot to stick. Where compressed air power cleaners are used, the compressed air serves to blow out the soot as it is released. Boiler tubes and headers should always be carefully examined after cleaning.

Idle Boilers. — When a boiler is to be left idle for some time, it should be thoroughly cleaned and dried out. Trays of hot charcoal should be placed in the boiler for a short time. Trays of unslaked lime should then be inserted. Unslaked lime will absorb all of the moisture, preventing the boiler from rusting. The boiler should then be closed air tight. Care should be taken not to let the lime come in contact with any part of the boiler. After closing the boiler, it should be covered with a coat of linseed oil. The fittings should then be painted. A boiler should not be left idle, full of water, for any length of time. If the boiler is, however, used a part of the time, it should be kept full of water when not in use. In this case, it is also advisable to add a little burnt lime to the water. Before a boiler is placed in commission, after having remained idle for a time, it should be thoroughly cleaned. When a boiler is to be left idle, the furnace, combustion chamber, and tubes

should be cleaned to remove the soot, thereby preventing unnecessary corrosion. If an idle boiler is not properly cared for, it will deteriorate much faster than a boiler in constant service.

Damper Regulators. — Where damper regulators and non-return valves are both used, great care should be exercised in locating the steam connection of the regulator to the main system. If this connection is made in the main steam system, and a break should occur, the steam pressure will fall, closing the non-return valves and also opening the damper regulator, thus putting full draught on the boilers when the main valves are closed. To avoid this, the connection for the damper regulators should be made between non-return valves and the boilers.

Guarding Stokers, and Coal and Ash Handling Machinery. — All gearing on stokers, and coal and ash handling machinery, should be as completely enclosed as possible by substantial cast iron covers, so designed as to be readily detachable.

All set screws, keys and bolts in moving parts should be covered or countersunk. Unused portions of keyways should be filled. The intake of exhaust fans and blowers should be guarded with a substantial wire-mesh screen.

Platforms, Stairways and Lighting.—A system of railed walks or runways should be erected to give convenient access to overhead valves, water columns, and other accessories. Railed walks should extend from one boiler to another of the same battery. Railed platforms should be constructed for the convenient and safe operation of individual valves.

Walks, stairs, ladders, and platforms should be well lighted and free from breaks and obstructions. They should be of substantial iron construction. Checkered steel plate or grids should be used for flooring, except in the vicinity of water columns, where gridiron construction should be used in order to permit a clear view of the water column from the boiler room floor. Railed stair-

ways should be used in preference to ladders. Stairways should be placed at each end of overhead walks in a line of boilers, and, in a large plant, one or more intermediate stairways should be provided.

Red incandescent lamps should be suspended over important cut-off valves on branches from steam mains or headers, to facilitate locating them in an emergency. A protected incandescent lamp should be suspended near each water column.

Special attention should be given to securing good illumination throughout the boiler house.

Numbering Boilers. — Each boiler should be provided with at least three number plates (each having the same number), as follows: One on the front of the boiler, one on the rear, and one on the pipe between the boiler steam nozzle and the header, in such a position that it can be readily seen from the walk or platform on top of the boiler setting.

Tests and Inspections. — Boilers should be inspected internally at least once a year by an expert. In addition they should receive an external inspection quarterly. Boilers should be tested by tapping the inside and outside, noting the sound, which, in addition to a careful examination, will usually disclose any defects.

Where any doubt exists in regard to the exact condition of a boiler, after having been hammer tested, it should be subjected to a hydrostatic test. New boilers should always be thus tested. Boilers should always be subjected to a hammer test, in addition to a hydrostatic test, as the latter test does not disclose all defects. If burned metal is suspected, a piece should be cut off with a chisel. If burned or crystallized, the metal will break off, otherwise it will curl up.

All outlets and pipe connections should be carefully examined, as they are especially subject to corrosion. Seams should be inspected for cracks and grooves. If hidden cracks are suspected in longitudinal seams, the

rivets should be cut away and the plates parted and examined. Pitting is likely to occur about drum connections. Mud drums should be thoroughly cleaned and inspected. Careful attention should be given to the blow-off nipples, valves, piping and connections. All stays should be taut and in good condition. Waterlegs of vertical and locomotive boilers should be frequently cleaned. Connections to water columns should also be kept clean.

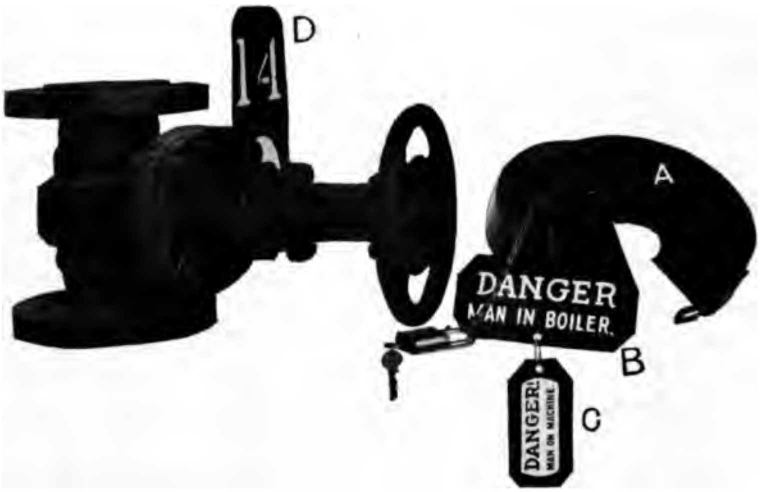


Fig. 13

Metal case for hand wheel of boiler valve, with padlock and danger tags.

Courtesy Illinois Steel Company.

Before starting a fire, there should be a proper amount of water in the boiler, otherwise serious damage will result.

Precautions Before Entering a Boiler.— All valves on the steam connection, blow-off pipe, and feed water pipes should be locked closed. (Fig. 13.) Care should be taken to see that there is no pressure remaining in the boiler, before removing manhole or handhole covers. Frequently there is a pressure of a few pounds remaining in the boiler even when the steam gauge reads zero. This would be sufficient to blow off the manhole cover with considerable

force. Opening the safety valve or water column cocks will relieve any pressure which may remain after the water has been all blown out.

The boiler should be sufficiently cooled before entering. All manholes, handholes, and the damper should be opened, and all doors closed. This will afford a good circulation of air. If kerosene has been used in the boiler, or if there is a possiblity that gas or oil may be present, the boiler should be thoroughly ventilated before anyone is allowed to enter. No open lights of any kind should be allowed in or near the boiler until it has been thoroughly aired out, as an explosion might ensue. Before entering, a lighted candle, attached to a string on a stick, should be carefully lowered into the boiler, standing well away from the manhole. If any oil vapor, sewer gas, or other gas is present, it will then explode. This is an important precaution. It is far preferable to use a portable, electric hand lamp instead of any other illuminant. This should be covered with a wire guard, and all connections thoroughly insulated.

Before entering the combustion chamber, ashes should be removed. Sometimes ashes are merely wet down instead of being removed. This is a dangerous practice. A man might sink through a cool thick crust into red hot ashes. When thus treated, ashes retain considerable heat for several days. Wetting ashes also damages the settings.

Rotary Boilers, Digesters, Rendering Tanks, Bleachers, and Extractors. — The stock holes and mouth pieces of rotaries, digesters, rendering tanks, bleachers, etc., should be reinforced with wrought steel rings, compensating for the metal cut away. Cast iron should not be used, as it is not dependable.

Bisulphite digesters should receive weekly inspections. There is danger that openings may be formed in the lead lining, allowing the acid to eat its way through the shell. Numerous small holes should be drilled in the shell. Any leak in the lining may thus be quickly discovered before

the acid weakens the shell. The shells of digesters should be kept at a constant temperature, to avoid contraction or expansion.

When rotaries, driers, extractors, rendering tanks, digesters and other tanks are operated at a lower pressure than that of the boiler, the steam connection should be provided with a stop valve, reducing valve and safety valve. This is important, as these vessels are not usually constructed to withstand the full boiler pressure. The reducing valve should be set to reduce the steam pressure to that desired in the vessel. The safety valve should be set to blow off at the maximum pressure which the vessel can safely stand. The safety valve should be large enough to properly protect the vessel.

The above named boilers and tanks should be frequently and carefully inspected, both internally and externally, for corrosion, cracks, leaks, and other defects.

BOILER ROOM RULES

1. Employees, except those whose duties require it, should be strictly forbidden to go into the boiler room.

2. When coming on, or going off duty, be sure that the valves between the water column and the boiler are opened. Blow down the water column, noting the return of the water in the glass. Test the gauge cocks until absolutely sure of the water level. Water gauges are not always reliable. Then inspect the fires.

3. Be sure that the water level is maintained at the proper height at all times. If the water level does not fluctuate, it is a good indication that the gauge is clogged. Test the level by opening the gauge cocks, and if the level of the water in the boiler is not at the proper height, shut down the boiler, and repair and clean the water gauge.

4. See that the boiler steam gauges and water gauges are well lighted, so that there will be a clear view of the gauges at all times.

5. See that the water gauge glasses are provided with proper guards, to protect the eyes of anyone in case of breakage. Be sure that the guard does not obstruct a clear view of the water level.

6. Keep the water gauge glass in a clean condition.

7. Renew the glass in the water gauge, when it becomes too dirty for the water level to be clearly seen. Gauge glasses become chemically corroded, and partly eaten out in places, during a long period of service, especially if the water is bad, causing weakness in the glass. Gauge glasses, that have been in service for a considerable length of time, should be replaced with new ones. Many bad eye accidents and serious scalds are due to the breaking of water gauge glasses.

8. Always compare the steam gauge with the safety valve, when the boiler is blowing off, to make sure that they agree. If they do not agree, discover the reason, and make the necessary adjustments.

9. Make occasional tests of steam gauges, to insure that they are registering correctly.

10. Safety valves should be tested at least once a day by lifting them off the seat. See that the valves do not stick on their seats.

11. When the steam gauge indicates the maximum pressure allowable, be sure that the safety valve is freely blowing off.

12. Keep the safety valves well oiled.

13. Never allow the safety valve to be set to blow off at a pressure over the maximum allowed.

14. Never allow the safety valve to be blocked up, or otherwise made inoperative.

15. No valve of any kind should be allowed between the safety valve and the boiler.

16. See that a safe access is provided to all valves. Footways should be placed at the top of batteries, to render an easy and safe access to all appliances.

17. In case of low water, do not, under any circumstances, open the safety valve, or turn on the feed water. Do not touch the steam outlets. Cover the fire with wet ashes, and close the fire and ash pit doors. Then wait until the boiler has been cooled off, before making an examination to see what damage has resulted.

18. If a boiler starts to foam, close the throttle long enough to show the correct level of the water in the glass gauge. If there is sufficient water in the boiler, feed it, and blow it down. If this does not suffice, check the draught, and open the surface blow-off. If a boiler foams, there is some cause for it, which should be discovered and remedied.

19. When blowing off boilers, open and close the blow-off valves slowly.

20. Boilers should be blown off at least twice a day, preferably when coming on shift in the morning, and before starting up in the afternoon. At these times, scale or sediment has had sufficient time to settle near the blow-off.

21. Never allow a blow-off pipe to be placed in a passageway, driveway or other place, where it may cause injury to anyone.

22. Do not allow sediment or scale to accumulate in the boiler. Never allow any oil or grease to enter the boiler. These substances cause overheating, which is often the cause of explosions.

23. Be sure to use the proper compounds to prevent scale forming. See that they are used frequently in small quantities, rather than occasionally in large quantities.

24. See that the blow-off pipe is protected by brickwork from the direct flames of the fire.

25. Boilers should be washed out at least once a month, and more often, if the feed water is bad.

26. If anything prevents the water from being fed to the boiler, the boiler should be immediately shut down until repairs are made.

27. Never go into a boiler before you have closed and padlocked all valves and slides.

28. After the boiler has been drained, the blow-off valves should be locked closed.

29. The automatic valves should be frequently examined, to insure their proper action in emergencies, such as the bursting of tubes.

30. When opening up a cold line, the following precautions should be taken: —

(*a*) Open all available drips.

(*b*) Warm the line by opening the by-pass, when possible, or by opening the stop valve sufficiently to warm very slowly.

(*c*) An inexperienced man should not be allowed to turn steam into a cold line, unless accompanied by the foreman.

(*d*) Never open the main valve, until certain that the line is thoroughly heated.

31. Be sure that the steam gauge pressures register the same, before attempting to connect two or more boilers. Do not attempt to connect them, under any circumstances, until the pressures agree. In cutting a boiler in or out always use the by-pass, before opening the main valves. Should the non-return valve fail to work, immediately notify the proper authority.

32. Never clean or repair boilers, pumps or engines, until all valves leading to them are tightly closed and padlocked, with a danger tag, bearing your name, attached to the valve. Be sure the boiler is properly cooled before entering.

33. Never open a valve, leading to a boiler that is being cleaned or repaired, until you have seen that no one is inside.

34. Take great care to see that you open the right valve on the proper pipe line. Failure to use great caution in this respect has been the cause of many serious and fatal accidents.

35. All steam traps should be kept clean, and in working order. Traps are the only safe means of removing water from the line. Should a trap get out of order, and it be impossible to repair it at once, the by-pass should be opened sufficiently to pass all water that might collect.

36. Pipes should be well drained before any joints are broken, otherwise persons might be scalded, as the result of some pressure remaining in the pipes. Always close the main valves before breaking any joints.

37. Cut out, from the header, every boiler that is not in operation with the others.

38. Make frequent inspections of all valves, gauges and other appliances, and keep them in good working order at all times.

39. Report, immediately, any defects in boilers, brickwork, pipes, valves or other appliances.

40. Repair all leaks in boilers, pipes, flanges or gaskets, as soon as possible.

41. See that the boiler is kept dry on the outside, and that no cold air has a chance to enter through any cracks in the brickwork.

42. Open each door to the boiler at least once a day, and inspect carefully for leaks at all points. Carefully examine the fire sheets for bulges, bags or blisters.

43. Never attempt to calk a leaky seam in a boiler, steam pipe or valve casing, under pressure. The force of a hammer blow may cause disruption. Always use round nosed tools in calking.

44. Small leaks in the boiler are indicated by small white incrustations on the plates near rivets. These should be plainly marked before calking, otherwise, these slight indications may be obscured in handling and hammering.

45. Great care should be used in the cooling and handling of flue dust, as it is likely to fly and explode, causing bad burns.

46. Three men should always work together when cleaning flue dust from boilers. Two men should remain on the outside, ready to lend assistance, in case of accident. One should constantly remain in a position to see the man working inside.

47. In shutting down a boiler before cleaning, it should not be blown out under pressure, or rapidly cooled. The boiler and brickwork should be cooled before emptying the boiler. If these precautions are not taken, sediment and scale will be baked on the shell or tubes. Serious stresses are set up in the shell or tubes, where the boiler is allowed to cool rapidly, and this will cause trouble later on. Boilers should never be blown out, and immediately filled with cold water. Be sure to maintain the level of the water in the boiler, until it has cooled sufficiently.

48. Before cleaning a boiler, be sure that all valves are closed and padlocked, and that the steam gauge indicates no pressure; lift the safety valve from its seat; then admit air at the top, open blow-off cock, and allow the water to run out. Wash the boiler out from the top manhole, with hose under good water pressure, in order to remove all loose scale; then open the lower manhole and handholes. See that all scale is removed from every part of the boiler or tubes, and between the tubes. Inspect carefully for defects, especially where that part of the boiler is subjected to the direct heat of the flames. Carefully examine every part of the boiler and accessories. Repair all defects found, before putting the boiler into commission again. Clean out all ashes and soot on the grates, plates, heads, tubes and in the combustion chamber. Never neglect to clean out a boiler thoroughly, after it has been hammered or calked.

49. Never entirely close the damper, when there is a fire on the grates. Gas may collect, and cause a serious explosion.

CHAPTER VIII

ENGINES

THE care and operation of engines should be entrusted to a competent engineer who has had considerable experience in this line of work. He should have at least one assistant who is also familiar with the operation of engines and locations of valves and appliances.

Guarding Engines. — All platforms, footways, and stairways about engines and pumps should be provided with handrailings and toeguards. Stationary iron stairways or ladders should lead to all emergency valves which cannot be reached from the floor or a platform. Properly railed steps should be provided where the main bearings cannot be readily reached from the floor.

Cross-heads and connecting rods should be guarded with a substantial pipe railing, at least 3½ feet in height, consisting of two horizontal members. This railing should be placed at least 15 inches from the moving parts. If the railing is placed within this limit, it should be filled in solid with wire mesh. Cranks, eccentrics, and tail rods should be guarded by a suitable enclosure, or properly railed off. Governor sheaves should be enclosed. The fly-balls of governors should be provided with a substantial basket guard of wire mesh.

Fly wheels and belts of all steam engines, gas and oil engines, and air compressors should be enclosed to a height of six feet, where necessary for safety, by a substantial fence, preferably built of pipe railing or angle iron, and filled in with wire mesh. If a simple pipe handrailing is used, it should be at least 3′ 6″ in height and double railed. (Fig. 14.) It should be placed at least 18 inches from the

nearest parts of the fly wheel. If the fly wheel runs in a pit, the railing should, in addition, be provided with a toeboard to prevent anyone slipping into the pit. Where

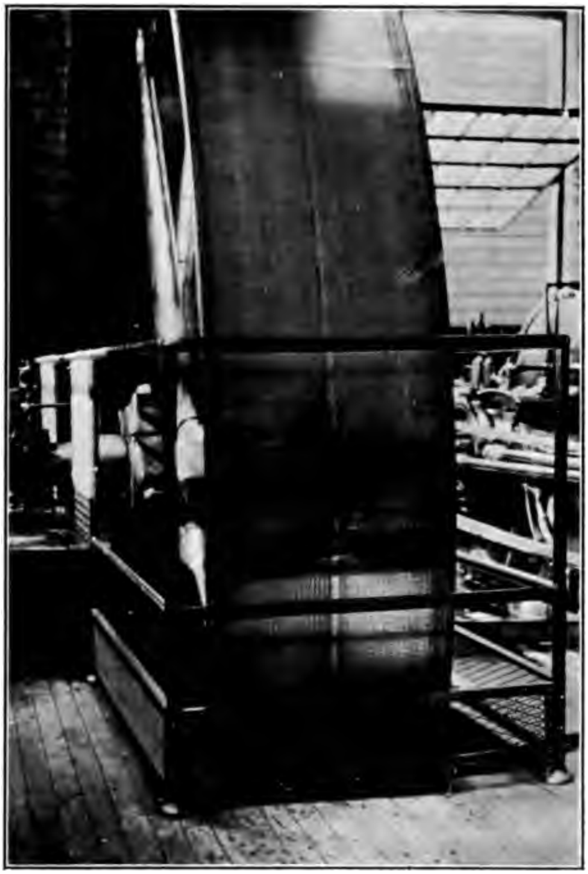


Fig. 14
Properly guarded fly wheel.
Courtesy Goulds Manufacturing Company.

it is necessary to obtain access to the fly wheels of gas or oil engines in order to start them, the fence may be provided with a hinged door. No articles or clothing should be left within the fence or hanging on the railing. Where

it is necessary to use the space under an inclined drive belt, the belt should be protected underneath and on the sides by a substantial suspended guard. Removable guards of the socket type may be used for fly wheels of gas engines where lack of space will not permit the use of a hinged door, but they should be substantially braced.

If a gas engine is equipped with a gas bag regulator, the bag regulator should be completely enclosed in a tight metal case, vented to the outside atmosphere.

Fly Wheels. — The function of a fly wheel is to store up and restore periodical fluctuations of energy given to, or taken from, an engine or machine, thus keeping the velocity of rotation approximately constant.

For any given material, the strength to resist centrifugal force depends only upon the velocity of the rim, and not upon its bulk or weight.

The principal causes of rupture are due to overspeeding, breaking or slipping of the governor belt, defective governor mechanism, faulty design of the fly wheel, sudden decrease of load, overload, insufficient strength of the flanges and bolts, defective material, and breaking of the main belt.

The safe rim speed limit for cast iron wheels in one piece, assuming a breaking strength of 10,000 lbs. per sq. inch, is 100 feet per second. For cast steel wheels in one piece, assuming a strength of 60,000 lbs. per sq. inch, the limit of safe rim speed is 233 feet per second. These calculations are based upon a factor of safety of ten (10).

If the wheel is made in halves or sections, the strength is greatly decreased. For belt wheels with flanged and bolted rim joints between the arms, the joints average only $\frac{1}{5}$ the strength of the rim. This type of joint cannot be designed with a strength greater than $\frac{1}{4}$ that of the rim. If the rim is thick enough to permit reinforcement by means of steel links which are shrunk on, $\frac{1}{3}$ the strength of the rim may be attained. This construction cannot, however, be applied to belt wheels with thin rims.

The stress in a wheel varies as the square of the speed. The factor of safety on speed is the square root of the factor of safety on strength. A factor of safety on the strength of at least 9 is recommended, which is equivalent to a margin of safety of 3 on the speed.

The diameter of fly wheels for various speeds may be found by the formula $D = V/\pi R$, in which V is the maximum velocity of the rim allowable, and R the number of revolutions per minute.

For a given material there is a definite speed at which disruption will occur, regardless of the amount of material used.

Mr. Boehm of the Fidelity and Casualty Company gives the following formula — $V = 1.6\sqrt{S/W}$, in which V is the velocity of the rim of the wheel in feet per second at which disruption will occur, W the weight of a cubic inch of the material used, and S the tensile strength of 1 sq. inch of the material.

Mr. Boehm also recommends the following table of safe revolutions per minute of cast iron wheels of different diameters. The flange joint is taken at 0.25 of the strength of a wheel with no joint; the pad joint, that is, a wheel made in six segments, with bolted flanges or pads on the arm is taken at 0.50; and the link joint at 0.60 of the strength of a solid rim. The table is figured for a margin of safety on speed of approximately 3, which is equivalent to a margin of stress developed, or factor of safety in the usual sense, of 9:

TABLE OF SAFE REVOLUTIONS PER MINUTE FOR CAST IRON WHEELS

Diam. in feet	No joint R.P.M.	Flange joint R.P.M.	Pad joint R.P.M.	Link joint R.P.M.
1	1910	955	1350	1480
2	955	478	675	740
3	637	318	450	495
4	478	239	338	370
5	382	191	270	296
6	318	159	225	247
7	273	136	193	212
8	239	119	169	185
9	212	106	150	164
10	191	96	135	148
11	174	87	123	135
12	159	80	113	124
13	147	73	104	114
14	136	68	96	106
15	128	64	90	99
16	120	60	84	92
17	112	56	79	87
18	106	53	75	82
19	100	50	71	78
20	95	48	68	74
21	91	46	65	70
22	87	44	62	67
23	84	42	59	64
24	80	40	56	62
25	76	38	54	59
26	74	37	52	57
27	71	35	50	55
28	68	34	48	53
29	66	33	47	51
30	64	32	45	49

The stress, due to centrifugal force, in the rim of a fly wheel of any given material may be found by the formula $S = W.V/2.66$ in which W is the weight of the material in lbs. per cubic inch, and V is the rim speed in feet per second.

Wooden rims, if properly constructed, are preferable to cast iron rims, and cast steel is preferable to either. Wire wound rims for fly wheels are used for especially high speeds.

Under no circumstances should the fly wheel be allowed to exceed the safe speed limit. The fly wheel should be large enough to eliminate wide variations in the speed due to great variations in the load.

Fly wheels should be frequently and carefully inspected. Failure usually starts in the form of a small crack near an arm on the under side of the rim. These cracks gradually enlarge until the wheel breaks at this point. Bolts in sectional wheels should be examined to see if they are sufficiently tight.

Governors and Safety Stops. — Engines should never be operated without an efficient governor. If not of the shaft or fly wheel type, the governor should be driven by at least three independent ropes. The governor sheaves should be keyed to the shafts, the unused portions of the keyway being filled in flush with the surface of the shaft. Each engine should be equipped with an independent, automatic, speed limit engine stop. Those that are not thus equipped, should be provided with an approved safety device which will automatically shut off the power, if the governor should, for any reason, fail to act when the load is removed.

Devices are used which are designed to shut off the steam supply in case the governor belt should break or slip. The governor should never be supported by a fixed pin when the engine is in operation. To guard against the danger of the engineer forgetting to remove the pin supporting the governor, before the engine is started, an automatic pin support should be used. This should be so designed that, when the engine is started and the speed increased, the pin support will be automatically removed, thus leaving a clear path for the governor collar to descend when the load on the engine is decreased.

Independent, Automatic, Speed Limit Stops. — It is important that engines be equipped with independent safety stops and speed limit devices with push buttons located conveniently in each workroom to guard against

possible fly wheel wrecks, and to allow the machinery to be quickly stopped in case of emergency. Electrical connection should be made to push buttons. The closing force which actuates the mechanism should be obtained by means of gravity. The device should be designed to effectively prevent the engine from overspeeding from any cause whatever. It should be impossible to reset the device without previously turning down the hand wheel, thus eliminating the danger of suddenly throwing a full head of steam on the engine. A low speed detector should be provided, which will give positive warning in case of failure of the driving connection between the engine and the speed limit. The speed limit device should be driven from the engine shaft at a speed several times that of the engine, thus making it far more sensitive than the governor. These devices may also be used on various types of steam turbines, oil and gas engines, and water turbines.

Conspicuous "ENGINE STOP" plates or placards should be located at each push button. There should be clear access to push buttons at all times.

Daily tests and inspections of all the above mentioned safety devices and governor mechanism should be made. Data regarding all tests and inspections should be recorded on forms provided for the purpose. An accurate record should be kept on file.

Receivers. — Receivers should be equipped with a relief valve of ample capacity which should be set to blow off well within the safe working pressure of the receiver and the low pressure cylinder. These valves should be frequently tested. The steam connection to the receiver should be provided with a reducing valve to lower the pressure of the receiver. Provision should be made to relieve condensation.

Automatic Vacuum Breakers. — Where engines are run condensing, they should be equipped with an automatic vacuum breaker in addition to the engine stop. This may

be operated electrically in connection with the engine stop, instantly destroying the vacuum when the stop is tripped. Where several engines are connected to one condenser, a valve by-pass should be provided, which will exhaust the pressure between the valve and the engine into the condenser, thereby protecting the operation of the other engines. The vacuum is often sufficient to speed up an engine under no load to a point where the fly wheel disrupts from centrifugal force, even when the steam supply is entirely shut off. For this reason, it is necessary to have an automatic device to break the vacuum.

Automatic Circuit Breakers. — When two or more direct connected units are operating in multiple, and one of them is to be shut down, it is desirable to have a circuit breaker connected to the generator in order to break the circuit at the same time that steam is shut off from the engine. The function of the circuit breaker is to prevent the generator from running away with the engine when the supply of steam is cut off.

Steam Separators. — Steam separators should be used in order that the engine may receive dry steam. They should be placed in the supply pipe as near the throttle as possible. A separator is also of value in maintaining an even flow of steam and of eliminating steam vibrations from the pipes. It is also a safeguard for catching bolts, nuts, or other material which might be carelessly left in the steam pipes when erecting new work. Otherwise, these articles might be forced into the cylinder, resulting in the blowing out of a cylinder head. Care should be taken to see that the automatic drain trap is always in working order. All separators should be equipped with glass gauges and covered with heat insulating material.

Air Compressors and Receivers. — Compressors should be equipped with a speed limit governor to prevent the engine from overspeeding in case an explosion or break in the air receiver or pipe line causes a sudden lowering of pressure.

Great care should be taken in the use of lubricants for the cylinders of air compressors. The oil should have as high a flash point as possible, consistent with proper lubricating qualities. Only pure mineral oil should be used in as small amounts as is absolutely necessary. Pure mineral oil will tend to prevent the accumulation of carbon which interferes with the operation of the valves.

Kerosene oil should never be thrown into the inlet of an air compressor in an attempt to clean the cylinders, as an explosion might result.

Air receivers should be equipped with a pressure gauge, drains, and a safety valve. Air receivers, including the gauges, drains, and valves, should be frequently inspected and tested. Numerous explosions result from a failure to make frequent examinations of the receiver and its accessories. The air pipe line should be properly drained. The intake pipe to the compressor should be screened.

Lubrication. — Wherever possible, engines and machinery should be equipped with automatic lubricating devices to eliminate the necessity of hand oiling while the machinery is running. This does away, to a great extent, with the danger of attendants being caught or struck by moving parts.

It is of great importance that the correct kind of a lubricant be chosen for the particular use to which it is adapted. The flash point should be as high as is consistent with the requirements.

Piping. — Systems of steam piping should be laid out with great care. Proper provision should be made for expansion and contraction. This may be accomplished by the use of loops or bends, and, if necessary, by expansion joints. The pipe system should be anchored at certain points in such a way that the pipe will be absolutely fixed at these places. Great care should be taken to see that expansion does not throw any undue strain on any part of the pipe system, nor on the steam chests of engine cylinders.

Copper and cast iron should not ordinarily be used for steam pipes, as they are unreliable for high pressures. Copper is so affected by heat and steam that its tensile strength is greatly reduced. Steam pipes should be constructed of wrought iron or steel. The limit of elasticity in cast iron pipe is reached at a steam pressure of from 140 to 175 pounds. Under such conditions the metal is unduly strained. Cracks are then formed, which will sooner or later result in the bursting of the pipe.

Fittings of cast steel or malleable iron should be used in place of cast iron. So far as possible, fittings should be displaced by the use of nozzles. This is accomplished by welding one section of wrought steel pipe to another. This makes the line tighter and stronger, eliminating many joints. The old fashioned screw joint is unsuitable for high pressures and superheated pipe lines.

Flanges should receive a fine tool finish, resulting in a perfectly smooth face. Corrugations on the face are unnecessary if proper gaskets are used. Corrugated steel or monel metal gaskets should be used except in special cases. Copper gaskets are undesirable on superheated steam lines, as the copper is acted upon by the steam.

Bends of long radius should be used in preference to those of short radius. Where possible, right angle connections should be avoided.

Gate valves are preferable to globe valves in most cases. Gate valves on high pressure lines should be equipped with a by-pass. This should be used to equalize the pressure on each side of the valve, before the valve itself is opened. This allows the cold section to be thoroughly warmed before full pressure is turned on. It also prevents waterhammer. Globe valves should not be used on indicator pipes. For water pipes, a gate valve or stop-cock should be used to obtain a clear passage. Valves should be so placed as to prevent the formation of a water pocket.

Pipes should pitch in the direction of the flow of steam. Drip pipes should be placed wherever water pockets are

likely to form. They should be kept well drained. Where there is a possibility of stoppage or flooding, drips should not be connected to drains. Engine drips, throttle drains, and separator drains should not be connected. All drips should preferably run independently to a separate trap or outlet.

Traps should always be used in place of valves to drain headers and other important connections, such as drop-legs, separators, and receivers. Traps should be so located that their operation can be seen at all times. Drop-legs, receivers, and separators should each be equipped with gauge glasses. Steam traps should be frequently examined to insure safe removal of water from the line. Where there is a rise in the main, a drip pipe should be located at the lowest point just below the rise. Mains and important branches should terminate in a drop-leg, which should be tapped for a drain.

Where engines are run condensing, the connection to the condenser and exhaust pipe should be so placed that water cannot possibly be drawn into the cylinder. A relief valve should be placed in each end of the cylinder. These valves should be frequently tested. Jet condensers should be equipped with a float operated vacuum breaker, which will open when the water in the condenser rises to a certain level, thus preventing water from entering the cylinder. An automatic relief valve should be placed in the exhaust pipe. Provision should be made for draining the exhaust pipe. All exhaust pipes within 10 feet of the ground should lead to exhaust pits, provided with metal covers, thus preventing the steam from burning a passerby.

Steam pipes should be frequently blown out to clear them of accumulations. They should be neatly covered with heat-insulating material to prevent condensation so far as possible. Ample provision should be made for contraction and expansion throughout the line.

In a large plant, where there are many pipe lines carrying different fluids, it is advisable, in order to avoid con-

fusion, to paint each line a different color. This will tend to prevent mistakes in opening the wrong valve or breaking the wrong line. Colored pipe line charts should be kept at convenient places. Pipe-men and assistants should refer to them until thoroughly familiar with all the lines.

Engine Rooms. — Corrugated rubber, cocoa-matting, or some other material which will prevent slipping, should be placed on the floor near machines. The sockets of tool racks should be painted a bright color to emphasize the absence of any tool which may become carelessly misplaced. Floors should be kept free from oil and other accumulations. Engines and other machinery should be kept well lubricated and scrupulously clean. The engine room should present a neat and tidy appearance.

ENGINE ROOM RULES

1. Employees should be strictly forbidden to enter the engine room, except for a special mission, and then should remain only as long as necessary.

2. The engineer should be forbidden to leave the engine room, until some other attendant, who is thoroughly familiar with the engines, valves and signals, is summoned to take charge.

3. No person, other than those responsible for the operation of the engines, should be allowed to touch any valve or other part of the mechanism, or approach any moving part.

4. No one, except the attendants, should be permitted to go inside the railings, or upon footways, when the machinery is in motion.

5. The safe speed for each fly wheel should be known, and in no case should this speed be exceeded. Fly wheel revolutions should be recorded every day, in order to make sure that the engine is not running over the speed limit.

6. All parts of engines and accessories should be frequently and thoroughly inspected, and daily tests should be made of the governor mechanism and automatic engine stops.

7. Before going into an engine or pump, be sure that the fly wheel and crosshead are blocked, so that a leak of steam cannot start the engine.

8. Be sure to place danger tags and locks on valves, before going into an engine or pump, or to work on machinery, and notify the engineer or operator.

9. Under no circumstances, should engines be started until they are thoroughly heated by alternately blowing live steam through each end of the cylinders, and the steam pipe and cylinders thoroughly drained of all water. The drips should be left open, until the load is put on, and then closed. Be sure to warm up the engine at both ends.

10. In shutting down, the drip valves should be left closed, until the engine is stopped. If the throttle is equipped with a by-pass valve, the throttle should

be closed, and the engine stopped with the by-pass. This gradually stops the engine, avoids the pumping effect of the piston, and prevents water being drawn into the cylinder and trapped, when compression occurs.

11. Never attempt to " bar" a fly wheel around off center, nor pull it off center by grasping the belt, when the steam pressure is on.

12. Never start to take a piston out of a cylinder, without making sure that the throttle and exhaust valves are both shut tight, and locked, and the drains wide open; nor without trying the indicator cocks to see whether there is any pressure on.

13. Never stop the air pump before stopping the engine (condensing), as the condenser and exhaust pipe may be flooded, and overflow into the cylinder.

14. All steam traps should be kept clean, and in working order. Should a trap get out of order, and it be impossible to repair it at once, the by-pass should be opened sufficiently to pass off all water which might collect.

15. Leaks in pipes, flanges or gaskets should be repaired at the earliest possible time.

16. In opening up a cold line, all available drips should be opened. The line should be warmed by opening the by-pass, where possible, or by opening the stop valve sufficiently to warm very slowly. Never open the main valves, until certain that the line is thoroughly heated. An inexperienced attendant should not be allowed to turn steam into a cold line, until properly instructed.

17. Automatic valves should be frequently examined, to insure their proper action in emergencies.

18. Under no circumstances, should vacuum-breakers, governors, engine stops or other safety devices be blocked, or otherwise made ineffective. If such apparatus gets out of order, it should be reported at once.

19. Do not stand in front of cylinder heads of engines.

20. Do not place any material, tools, etc., on platforms or stairs around engines. They might fall off, and injure someone below.

21. Never work in a gas engine room alone; always have a helper with you.

22. If you find a man overcome with gas, get him into the open air at once. Notify the foreman.

23. Smoking and open lights should be forbidden around gas machinery and gas pipes; otherwise, an explosion might result.

CHAPTER IX

ELEVATORS

UNLESS properly installed and equipped, safeguarded, maintained in excellent condition, frequently inspected and carefully operated, an elevator remains one of the most dangerous of machines. Insufficient attention is usually given to these important features. As a result, accidents from this source are very frequent. When an accident occurs on an elevator, it is usually of a serious or fatal nature. Employees and others, whose duties require them to ride on elevators, naturally assume that all necessary precautions have been taken by those in authority to insure their safety. Unfortunately, however, in many instances, no such precautions are taken. Thus human lives become needlessly jeopardized by lax methods of supervision and maintenance.

Shafts. — Both passenger and freight elevator shafts should be solidly enclosed from top to bottom with fireproof material. Such construction offers more stability to the guide rails from side thrusts and stresses caused by the car. It also allows the use of continuous guide rails which would otherwise be cut at each floor. The necessity of using automatic hatch doors is eliminated; loose articles are prevented from accidentally falling into the shaftway; and persons are also prevented from being injured by contact with the car or the counterweight. The interior of the wall of the shaftway, which is used for entrance, should be smooth and even over its entire surface, offering no projections or depressions by which a person might be injured. All depressions in this wall should be filled in flush with the interior surface. All

projections, such as bolts and timbers, should be cut off flush or beveled.

If windows are placed in the walls of the shaft, they should invariably be constructed of wire glass set in metal frames. Skylights, if used, should also be of this construction.

No wiring, piping or shafting, other than that used in connection with the elevator, should be allowed inside the shaftway. In the case of enclosed, fireproof, freight elevator shaftways, automatic fireproof doors should be provided at all entrances. These should be held open by means of fusible chain links, the doors closing automatically in case of fire.

A large proportion of freight elevators have not, however, been installed in enclosed fireproof shaftways. On the contrary, shaftways are frequently of open construction, with no protection other than automatic hatch doors at each floor. These offer practically no protection to a person from injury, merely serving to check the draught in case of fire. If gates are not provided, employees are not infrequently found using automatic hatch doors, when shut, as a passageway from one part of the floor to another. Where the shaft is not enclosed on the unused sides, an employee may also be injured by leaning upon or over these doors when opening.

In order to insure safety, the unused sides of open shaftways should be enclosed at each floor, including the basement, with substantial wire mesh, extending the entire distance between the floor and the ceiling; also, from the head clearance (approximately 7 or 8 feet from the floor) to the ceiling on entrance sides. For this purpose, wire mesh has the advantage of admitting useful light. The operator is also enabled to see trucks or persons approaching. He can accordingly regulate the movements of the car. The open spaces between the wires should not exceed 2″ in size, being small enough to prevent a hand being thrust through.

Safety treads should be used at all landings for passenger elevators. The floors at landings may be made of material which will prevent slipping; or, rubber mats in one piece may be used. Mats should not be allowed to become worn or frayed, otherwise they might cause persons to trip. Wooden floors at landings should be free from holes, splinters, unevenness, and loose boards. They should never be allowed to become slippery.

Where possible, windows of wire glass should be built in one wall of the shaft to permit daylight to enter. The entrance to the shaftway at each landing should be well lighted at all times when the elevators are in operation.

Clearances. — Sufficient clearance between the top of the car and the overhead rigging, and between the bottom of the car and the base of the shaft, should be provided to allow for the possible overrun of the car beyond its normal limits of travel. There should be a clearance of at least 4 ft. at the top, and 3 ft. at the bottom. These clearances will lessen the danger of a repairman or an inspector being crushed at these places. If the speed of the car exceeds 100 ft. per minute, additional clearance should be provided. It is advisable to increase the clearance one foot for each 100 ft. per minute of speed. The use of car bumpers of sufficient height, at the bottom of the shaft, affords additional protection. These bumpers positively prevent the car from descending beyond the safe limit.

Beveled Beams and Plates. — All floor beams, timbers, brick arches, and other projections in the entrance wall of the shaft, should be equipped with beveled plates consisting of smooth sheet iron, as shown in Fig. 15. It is also advisable to place a beveled plate beneath the car at the front edge of the platform. Gates may become out of order, or carelessly left open, allowing a person to approach the edge of the shaftway before the car arrives at the landing. In this way, a foot, or some other part of a person, might be caught and crushed by the shearing action

of the descending car and the floor. If a beveled plate is used, however, this danger is greatly diminished. Accidents caused by the shearing action of the ascending car and a floor beam, or a brick arch, are very frequent. It is usually the foot of a person which is crushed, but his head or shoulder may be injured in a similar manner.

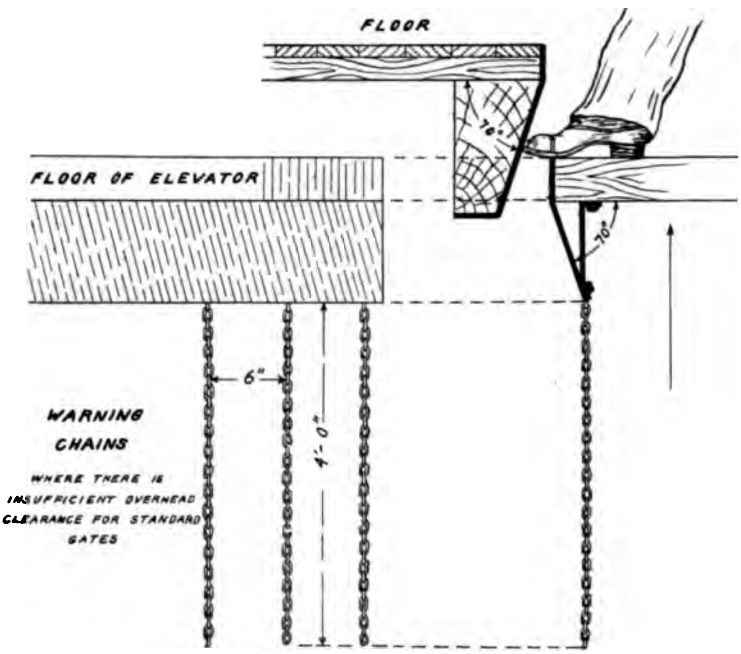


FIG. 15
Beveled beams and plates.

The plates should be perfectly smooth and closely fitted. They should be inclined at an angle of 70° from the horizontal. The inclination should never be less than 65°, otherwise they are of no value. To be effective, the plates should be at least 12″ in width. Operators and employees frequently become careless when on an elevator, allowing a foot, head or shoulder to extend beyond the edge of the platform as the car is ascending. If beveled

plates are not used, a serious accident will result. Where these plates are installed, a foot, head or shoulder would be automatically pushed back within the confines of the car, thus preventing a bad injury. In any case, the removal of a person's foot, head or shoulder from the danger

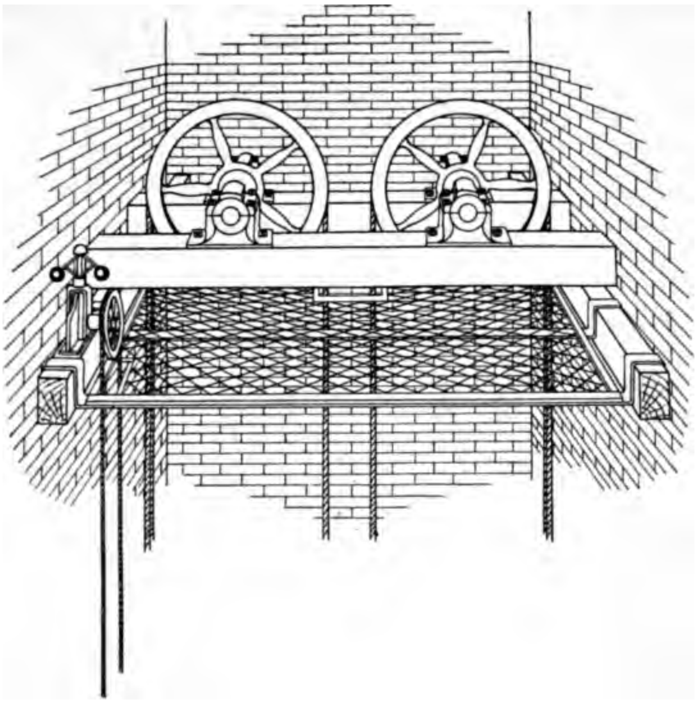


FIG. 16
Platform under sheaves and speed governor.

zone will be greatly facilitated. The importance of providing adequate beveled plates for floor beams, arches, and other projections in the shaftway, cannot be too strongly emphasized.

Platform Under Head Sheaves. — A substantial grating or platform should be placed at the top of the shaft directly underneath the head sheaves. (Fig. 16.)

A platform of this character permits a safe footing for inspection and repair of the overhead rigging. It also

prevents tools, broken parts, and other loose articles from falling down the shaftway. It should be strongly built and securely fastened to the supports. If an iron grating

FIG. 17
Interlocking devices prevent accidents of this type by positively locking the doors to elevator shaft until opened by operator after the car arrives at the landing.
Courtesy Safety Appliance Company, St. Louis.

is used, the width of the spaces between the bars should not exceed 1″. Open spaces in wire mesh should not exceed this size. If the hoist is located at the top of the shaft, a solid platform should be constructed. Access to the overhead platform should be obtained by an entrance above

it, eliminating the necessity of climbing upon it from the top of the car.

Doors. — Entrances in the shaftway to passenger elevators should be provided with solid sliding doors at each

FIG. 18
An accident of this nature cannot possibly happen where elevator doors are equipped with interlocking devices.
Courtesy Safety Appliance Company, St. Louis.

entrance. The doors should preferably be of metal construction. The upper panels are frequently filled in with wire glass. It is very important that locking devices be installed on all doors, preventing anyone from opening them from the outside. The locking mechanism should

be so arranged that only the operator on the inside of the car can open the doors. Keys should, of course, be provided for unlocking the doors from the outside in an emergency. Interlocking devices which prevent the operator from starting the car until the doors are closed and locked, and which prevent the doors from being opened until the platform of the car is level with the landing, are useful in preventing many accidents.

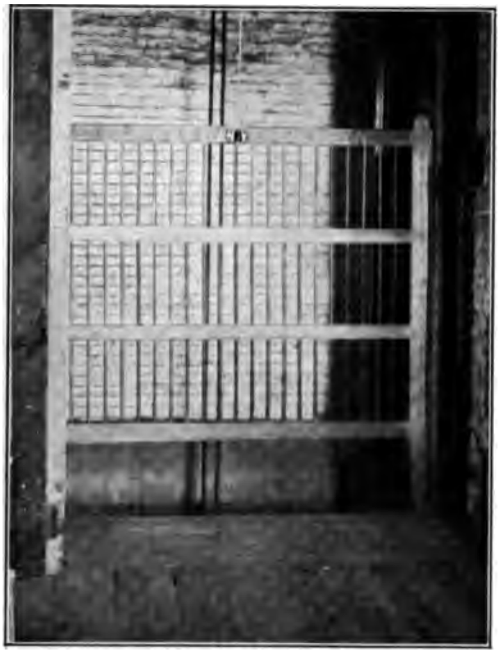


FIG. 19
Semi-automatic elevator gate of sufficient height at entrance to freight elevator shaft. Gates should preferably extend to floor level.

Gates.—Sliding doors at shaftway entrances to freight elevators, similar to those described for passenger elevators, are highly desirable in new installations. This equipment, however, is rarely encountered in the average factory.

All entrances to a freight elevator shaft, including the basement entrance, should be provided with substantial gates 6 ft. in height. (Fig. 19.) Gates should never be less than 5 ft. in height. Where there is insufficient overhead clearance for a gate of this height, a telescoping gate, consisting of two or more sections, should be used. If this is not feasible, a collapsible, horizontal sliding gate should be installed. Solid gates are undesirable; open construction should be employed, consisting of wire mesh or vertical wooden slats

or spindles. Open spaces in wire mesh should not exceed 2" in size. Vertical slats or spindles should not be spaced over 2" apart. Open construction has the advantage that persons are visible from either side of the gate. The gates should extend to within at least 2" of the floor, thus minimizing the danger of heavy objects, which might be carelessly dropped by employees, from rolling into the shaftway.

Gates should be of the semi-automatic type, being opened by hand after the car has been stopped at a landing, and closing by gravity as the car leaves the landing. Gates should be carefully counterweighted. The counterweights should run in an enclosure to prevent them from falling into the shaftway in case they become accidentally detached.

All gates should be provided with a locking device, preventing them from being opened by anyone on the outside of the shaftway. It should only be possible for the operator to open the gate from the inside when the car is at the landing. If it is possible for a person, standing on the outside, to unlock the gate by reaching with a hand or a bar, a metal guard should be placed over the latch or lock. Where locking devices on gates are not provided, many accidents are caused by careless employees opening the gates when the operator is away from the landing. Falls down the shaftway, and the crushing of workmen's bodies by the elevator, are then likely to occur.

Pivoted arms, bars, and chains should never be used in lieu of gates. They offer very little protection, are seldom in place, and are entirely inadequate. Upright hinged doors are also unsafe.

Semi-automatic gates are preferable to those of the full automatic type. Full automatic gates open whenever the elevator passes by. Employees may thus be injured while attempting to jump on or off a car as the automatic gates are opening.

Gates are often installed at all entrances to shaftways except in the basement. It is just as important to provide a gate at the basement entrance as at any other. Base-

ments, as a rule, are poorly lighted. Where no gates are placed at basement entrances, employees are apt to use the bottom of the shaft for a passageway. There is then considerable danger that they may be crushed by a descending car.

Where it is difficult to install a gate of sufficient height, warning chains, at least 4 ft. in length, should be attached to a beveled plate beneath the front edge of the platform of the car. These chains should not be spaced over 6″ apart. There should be no broken links at the bottom which might catch the clothing of a person. As the car descends, these chains will give warning by contact with anyone who may be carelessly leaning over a gate. This, however, is a makeshift device. It is much safer to use telescoping or collapsible gates of sufficient height.

Passenger Cars. — Passenger cars should be completely enclosed on three sides and protected with a substantial cover. Fireproof construction is preferable to any other. The sides should consist of solid panels extending upward to a height of 6 ft. The intervening space between the top of the panels and the cover should preferably be filled in with iron grille work. This open construction, above the panels, permits proper ventilation; it also aids illumination. The cover should be constructed with a hinged section, which will release upward, forming an emergency exit. In case the car is enclosed with iron grille work, containing open spaces large enough to permit a hand or foot being thrust through, it should be covered with wire mesh. This may be set in metal frame-work and attached to the sides of the car. The car should be provided with a sliding collapsible gate on the entrance side. This should always be closed and latched by the operator before the car is started. It should not be opened until the car has been stopped at the landing. Passengers should be completely confined within the car when it is in operation. There should be no possible chance of injury to passengers from the shearing action of the car with the shaft

ructure. Cars should have only one entrance. A sep-
ate freight compartment should never be placed above
· below passenger cars. The interior of the car should
e properly illuminated with electric lamps.

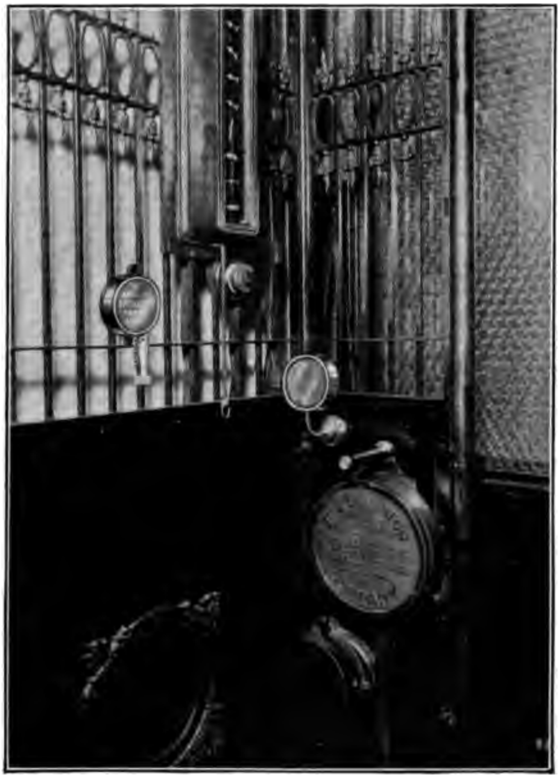


FIG. 20
Properly equipped passenger elevator showing correct location of controller and emergency switch. Cut also shows annunciator, and electric lamp, just above controller, which displays a red or a yellow light indicating that the door is open or closed respectively.
Courtesy Safety Appliance Company, St. Louis.

The flooring should be constructed of material which
ill prevent slipping. The floor should present a smooth
ırface over its entire area. Wooden flooring serves very

well, provided it is kept in good condition. Floor guides for gates should be countersunk flush with the floor. There should be no smooth metal plates in any part of the floor. These might cause a person to slip. Rubber mats in one piece may be used for the floor covering.

The controller should be so placed within the car that the operator can open the door lock without withdrawing his hand from the handle of the controller. If a lever is used, it should be arranged to swing parallel with the doors. It should also be adequately guarded by means of a metal shield. This will prevent anyone from accidentally brushing against it, thus starting the car.

Freight Cars. — The unused sides of freight cars should be enclosed to a height of at least 6 ft., and preferably to the bottom level of the overhead cross beam. For this purpose, sheet steel or solid wooden construction is desirable. Wooden slats and wire mesh are also satisfactory. If this open construction is used, the width of the spaces between the slats, or between the wires, should not exceed 2". That part of a side, directly opposite a counterweight runway, should be built solid, or covered with close wire mesh. A space should be left open on one side of the car to facilitate the operation of the shifter cable. Proper enclosure of a freight car is not only essential to safety, but it also saves time in handling and placing material on the car.

The car should be provided with a substantial cover, to prevent falling objects from injuring the operator or other employees. This should be constructed with a hinged section on the entrance side. This hinged section should be arranged to automatically release upward, in case it should strike a person's head or shoulder when leaning over a gate of insufficient height, as the car is descending; or, in case it should meet with any other obstruction.

Cars should preferably have but one entrance, although many cars are in use which have two. New building con-

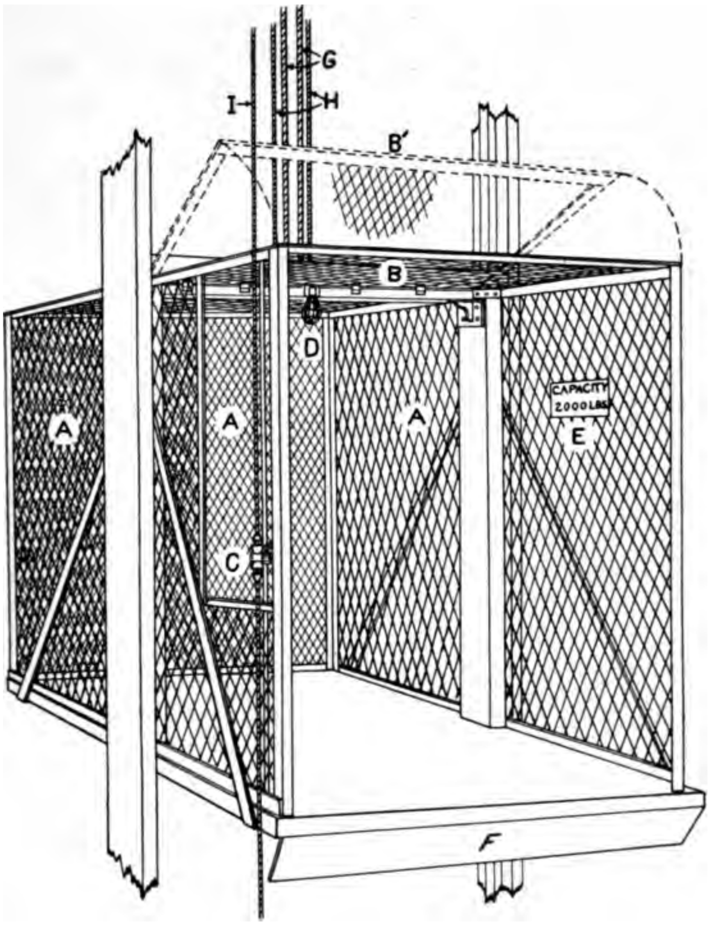


Fig. 21

Elevator car.

A Unused sides of car enclosed.
B Hinged cover.
B' Position of cover when raised.
C Elevator lock for shifter rope.
D Electric lamp covered with a wire basket guard.
E Capacity sign.
F Beveled plate on entrance side.

struction should be so designed that there need be only one entrance to each car, thereby minimizing the danger of persons being injured. The car should be provided with an electric lamp, protected from breakage by a wire enclosure. Proper illumination of cars is important. Where daylight is inadequate, artificial light should always be used.

The floor of freight cars should present a smooth, even surface, free from holes, splinters, smooth metal plates and protruding nails or bolts. It should not be allowed to become slippery or badly worn.

Where handcar tracks are used on a freight car, they should be countersunk. The top of the rails should be flush with the floor. Catches should be placed at both ends of one rail to block the wheels of the handcar, preventing it from rolling in either direction.

Safety Devices. — All passenger elevators, which are suspended by cables, and new installations of freight elevators, should be provided with an effective safety device of the clamp type, which is operated by means of a speed governor. This is the only reliable safety device in use which will positively prevent the car from falling, in case the cable should break or the winding mechanism fail. Even then, the safety device must be properly adjusted, and carefully and frequently inspected, to insure its proper action in an emergency. The device should be designed to grip the guides with a gradually increasing pressure, avoiding a severe shock. If the car is operated at high speed, speed governors are also desirable on machines. They are also being used, to some extent, in connection with counterweights, operating a clamp safety device on the counterweight frame. Counterweight governors should be located directly over the counterweight runway.

All freight cars, including hand operated cars, if not provided with a safety device which is operated by a speed governor, should be equipped with a quick operating safety device, actuated by a spring. This device should be oper-

ated by a breaking cable mechanism, preventing the car from falling in case the cables break. Where wooden rails are used, the device usually consists of sets of dogs or cams, faced with teeth, which, when operated, strongly grip the guides before the car has had a chance to fall more than a few inches. In case of steel rails, corrugated hardened steel rollers are commonly used, which, when the device is operated, are forced into a wedge-shaped recess between the shoes and the guide.

Quick acting safety devices, actuated by a breaking cable mechanism, are not, however, thoroughly reliable. If the cable should break near the winding drum of a machine which is located in a basement, the weight of the cable, and the friction caused by the cable passing over the head sheaves, would be sufficient to prevent the operation of the safety device. Gears, which operate the winding drum, may also be stripped. In this case, the tension in the cable, caused by friction in unwinding, would similarly prevent the safety grips from acting. This form of safety device would also be useless if the car should, through some defect in the winding mechanism, exceed the safe limit of speed. For these reasons, it is safer, in all cases, to use a speed governor. Safety dogs and rollers should not be allowed to become gummed with grease and dirt. They should be kept clean, and lubricated with light oil. Care should be taken to see that they are in proper adjustment. The governor mechanism should also be kept well lubricated. Guides should not be dressed with heavy grease. This may cause the dogs to become so gummed that they will fail to act.

Passenger cars, which are operated by an electric motor, should be equipped with an emergency switch, which will shut off the power and apply the machine brake in case of emergency. If the shaft is a deep one, it is often advisable to provide an emergency brake which can be operated within the car.

Automatic Limit Stops. — Wherever electrically oper-

ated cars are in use, limit switches, which automatically prevent the car from passing beyond the safe upper and lower limits of travel, should be installed in the shaftway. Automatic limit stops should be placed on all winding and traction machines, automatically shutting off the power and applying the brake when the car reaches the safe limit of travel at the top or bottom.

The brakes of electrical machines should be designed to tighten mechanically when the electric circuit is opened, and to release electrically when the circuit is closed. Belt drives should never be used on passenger machines.

A slack cable device, which will automatically shut off the power in case the cable becomes slack, for any reason, should be placed on all drum machines.

Lugs should be securely fastened at the top and bottom of the shifter rope of freight elevators, engaging a stationary stop which is located on the car, thus automatically shutting off the power before the car passes beyond the safe limits at the extremities of the shaftway.

Limit stops on the shifter rope of hydraulic elevators should be adjusted to stop the car a few inches above and below the top and bottom landings respectively. The back stop buttons should be adjusted to give the speed desired. Care should be taken to so adjust the limit stops that the car cannot strike the bumpers or permit the piston to strike a cylinder head. Limit stops, especially on a new rope, should occasionally be readjusted, if necessary, to compensate for stretching.

Automatic cut-off valves should be used in connection with all hydraulic engines, in addition to the operating valves. These will prevent the travel of the car from exceeding safe upper and lower limits.

Automatic Locks. — All freight elevators should be equipped with a locking device, by means of which the car can be securely locked at any floor, while material is being loaded or unloaded. (Fig. 22.) A lock of this kind will effectively prevent a person at any other landing

from starting the car during these operations. Where locks are not provided and used, injuries to operators and workmen from this cause are frequent.

Other types of locking devices should also be placed on shifter chains and rods, wherever they are used in place of ropes.

Signals. — Both freight and passenger elevators should be equipped with an approved electrical signalling system. Passenger cars should be equipped with annunciators, which signal operators to stop at a given floor. Indicators should also be installed at each landing, showing prospective passengers the relative position of the car at any point of its travel. Red and white electric lamp indicators may also be advantageously used; a red lamp should indicate that the car is descending, a white light that the car is ascending. In high office buildings, a telephone, which will enable the operator to talk with the starter, should be located within the car.

FIG. 22
Automatic lock for freight elevator.
Courtesy Angell Elevator Lock Co., Boston.

Freight elevators should be equipped with an electrical signal gong, which can be rung by push buttons located at each landing. It is also advantageous, in case the elevator serves more than three floors, to provide annunciators, which will indicate the floor from which the signal is given.

A suitable signalling system is highly important. The lack of signals, and the misunderstanding of signals, cause many accidents. Signalling by means of shouting, shaking the shifter rope, and tapping on rods, causes confusion. It is an exceedingly dangerous practice.

Counterweights. — Counterweight sections should be securely fastened together by means of headers and through bolts, or fastened by means of a clamp at the top of the sections which passes around the vertical rods.

Counterweight Runways. — Counterweight runways, which are located within the shaft, should be completely and substantially enclosed at the top and bottom for a distance of 9 ft. Enclosure is advisable at the top, to prevent the possibility of sections of the counterweight from falling upon the car. It is important to enclose the counterweight runway at the bottom of the shaft, to prevent anyone being crushed when the counterweight is descending, or from being injured by the shearing action of the counterweight with stationary projections on the wall of the shaft.

In case the counterweight runway is located outside of the shaftway, it should be completely enclosed from top to bottom.

Sheaves and Drums.—Sheaves and drums of too small diameter are frequently found in use. It is very important that the sheaves and drums be of sufficient diameter; otherwise, the rope will wear quickly, due to the excessive bending stresses in passing around the sheaves or drums. Wherever possible, idlers should be eliminated. They require the cable to pass through a reverse curve, which greatly increases the wear, due to constant bending back and forth. If necessary to use an idler, it should be as large in diameter as the main sheaves. The minimum safe diameters of sheaves and drums for lifting and counterweight cables of steel rope of 6 strands, 19 wires to the strand, are given in the following table:

Size of Cable	Minimum diameter of Drum or Sheave
$\frac{1}{4}$"	10"
$\frac{5}{16}$"	14"
$\frac{3}{8}$"	18"
$\frac{7}{16}$"	24"
$\frac{1}{2}$"	30"
$\frac{9}{16}$"	36"
$\frac{5}{8}$"	42"
$\frac{3}{4}$"	50"
$\frac{7}{8}$"	58"
1"	66"

Sheaves and drums should always be keyed to the shaft. They should never be fastened with set screws. Each shaft should be of the same diameter throughout, with no reduction in size at any point. Sheaves should be carefully aligned to eliminate uneven wear of the rope and the flanges of the sheave. Cable guards should be placed on sheaves and drums to prevent the cable, when slack, from running out of the grooves. It is also important that the grooves of sheaves and drums be of the proper size and shape to accommodate the cable. They should present a perfectly smooth bearing surface. Bushings should be renewed when worn, before the bearing can bind the shaft. Bearings should be kept well lubricated. Sheaves should be carefully examined for cracked spokes and other defects.

Location of Machines. — Machines should be placed in isolated fireproof compartments, which should be kept locked. There should be adequate room and sufficient light to permit a safe and thorough inspection of all parts. In addition to one or more stationary electric lamps, a portable electric lamp with an extension cord should be placed in the room. The portable electric lamp should be protected with a wire basket guard. Machines should never be located underneath the shaftway. They should never be placed in a dark, obscure or crowded place where it would be impossible to make a safe and careful inspection.

Hydraulic Machines.—Pressure tanks should be strongly built. They should be equipped with gauge glasses, manholes and safety relief valves. The latter should be large enough to discharge all of the water delivered from the pump without dangerously increasing the pressure. A stop valve should never be placed between the tank and the safety valve. If closed, for any reason, it would render the safety valve inoperative. Tanks should be internally inspected every two years for corrosion and other defects.

Piston rods are subject to corrosion. This is especially

true where the water is impure or acidic. Piston rods should be inspected once a year. If badly corroded, they should be immediately replaced. If the car creeps, it signifies that the packing is worn. In this case, repacking becomes necessary.

Cylinders should be properly lubricated, at least every three weeks, with animal oil or grease.

Sidewalk Elevators. — Sidewalk elevators, as a rule, are poorly safeguarded. Bars and chains do not afford proper protection for the opening. Collapsible gates should be used in connection with folding doors. It is preferable, in place of folding doors, to provide the opening with a suitable cover which may be raised or lowered by the car. The cover should normally be level with the surface of the walk. It should be connected to the car by means of vertical telescoping tubes at the corners of the car. As the car ascends, the cover will be raised. It will also be lowered as the car descends. Where such a cover is used, collapsible gates are unnecessary. In this case, chains may be used to guard the opening.

Hand Power Elevators. — Hand power elevators should not be used where the distance of travel exceeds 50 ft. The car should be equipped with a quick acting safety device, operated by a breaking cable mechanism. The car should be suspended by two lifting cables. The unused sides of the car should be enclosed to a height of 6 ft. A hinged cover, which will release upward if caught by an obstruction, should be placed over the car. Standard gates should be placed at all entrances to the shaftway. The shaftway should be completely enclosed on all sides which are not used for entrance. Practically the same standards should apply to hand power elevators as to machine elevators.

Dumb Waiters. — The shaftway of dumb waiters should be completely enclosed on the unused sides. Each opening should be provided with a vertical sliding door, so arranged that the carriage cannot be started until the

door is closed, nor opened until the carriage has stopped at the doorway. Speaking tubes should be installed in addition to an electrical signalling system. Caution signs and a table of signals should be placed near each opening. Employees should be especially warned never to thrust their heads or hands through any opening in the shaftway.

Cables.—All suspended freight elevator cars, car counterweights and drum counterweights, should each be provided with at least 2 cables — never with one alone. Passenger cars should preferably be suspended by 4 or 6 cables. Calculations for the load, which cables will safely carry, should never be based upon a factor of safety of less than 10 on the ultimate tensile strength. The tensile strength of each cable should be in the neighborhood of 90,000 lbs. per sq. in. Each cable should be independently fastened at both ends; otherwise, two cables will only serve as one. Where additional capacity is required, the number of cables, instead of the diameter, should be increased. Standard steel cables of 6 strands, 19 wires to a strand, with a hemp center, for both cars and counterweights, should invariably be used, unless it is desired to install cables with 37 wires to the strand. The latter are more flexible. Under no circumstances should lifting or counterweight cables be spliced.

The average life of a cable, subjected to ordinary wear, is about two years. In a cable of high efficiency, the wires should wear nearly half way through before fracturing. If the wires break prematurely, before they become noticeably worn, it is probably due to undersize sheaves or drums, or to too wide or too narrow grooves, which flatten or cramp the rope respectively.

The wear of a cable increases with the speed and the load. High speed will wear a cable faster than a heavy load, therefore, the load should preferably be increased rather than the speed.

As soon as cables begin to show signs of wear, they should be carefully watched. There is no definite rule

that can be laid down in regard to the number of wires which may become broken in a given distance before the cable should be condemned. Generally speaking, the cable should be replaced when 15% of the wires in several adjacent strands are fractured. One wire may be broken a number of times within, say, 100 ft., and still retain most of its strength, on account of the resistance caused by adjacent wires; whereas, if the breaks occur near together, most of its strength would be lost. Breaks that feel smooth to the hand, as it is passed over them, are not as severe as those which feel rough. When the broken wires slightly project, feeling rough as the hand is passed over them, or when they catch waste as the cable is rubbed with it, the cable should be discarded. Frayed cables are dangerous, indicating that the strength has been greatly reduced. A cable should not be used after it has lost 15% of its strength. If the wires in one strand are broken at a point where an adjacent strand passes over it, it indicates that the wires have started to break on the inside. Cables sometimes break first on the inside. When this condition occurs, the cable should be immediately condemned, as it is then problematical whether or not all of the wires on the inside of the strands are broken. If many of the wires in one strand are seriously broken or frayed at any one point, the cable should be immediately replaced.

Where any doubt exists as to the dependability of a cable, the safe course should be adopted, and the cable condemned. No chances should be taken, even if the cable is comparatively new.

In drawing wire cable from a reel, the reel should be mounted on axles, or rolled along the floor. The cable should be carefully unwound to avoid kinking or bending in the opposite direction from which it was wound upon the reel. The cable should not be completely removed at once from the reel, as it might be bent in the wrong direction when placing it around a sheave or a drum. Cables should be so placed upon sheaves and drums that

they will retain the same bearing surface as they had when wound upon reels.

In replacing a defective lifting or counterweight cable, it is better to replace all of the cables with new ones. The cables will then stretch and wear more evenly, as the tension will be equally distributed.

Where two counterweights run in the same slide, pipe sleeves should be attached to the cables of the lower counterweight. These should extend upward for a few inches above the top of the upper counterweight. These pipe sleeves will then receive all of the wear and chafing which would otherwise come on the cables of the lower counterweight, which run through the upper one.

Cables should be so placed on drums that, when the counterweight of the car is at the highest or lowest limit of travel, as the case may be, there will be at least two full turns of the cable on the drum.

Shifter ropes should receive an occasional inspection, being replaced before a large percentage of the wires become broken. Passing the hand along the rope will reveal its condition. If it feels very rough, it should be discarded.

Cables should be kept well lubricated with a mixture of graphite and cylinder oil. Lubricants should be free from acids and other corrosive substances. Cables should also be free from moisture.

The primary causes of failure of cables are due to external wear, internal abrasion, fracturing, and the so called crystallization of steel.

Cable Fastenings. — The thimble type of fastening consists of a curved oval thimble around which the cable is bent, the short end extending upward two or three feet. This should be clamped to the main length of cable with at least 3 properly fitted clips. There should be no sharp ends on the thimble, which might cut the cable, at the point where the arms converge. This form of fastening has the advantage of being readily accessible for inspection.

Socket fastenings, if used, should be made with great care. The wires should be frayed out at the end of the cable, and bent over or looped at the end. The bunch of wires should conform to the conical aperture of the socket. Molten babbitt metal should then be poured in, forming a solid conical fastening. Before pouring in the babbitt metal, the wires should be heated sufficiently to prevent chilling. The babbitt metal should not be heated to too high a temperature, otherwise the wires will be burned, greatly reducing the strength of the fastening.

Capacity. — The lifting capacity should be limited to 1/10 the breaking strength of the cables. In calculating the safe maximum capacity, the unbalanced weight of the car should be taken into consideration. The strength of the car should also be based on a liberal factor of safety.

Speed. — For local passenger elevators, usually stopping at all floors, the speed should not exceed 350 ft. per minute. In this case, the governor should be set to operate at a speed of 550 ft. per minute. Greater car speeds for local passenger elevators are undesirable. They often cause the operator to run the car past a given floor, in case he does not receive the signal in time to stop. This causes inconvenience and a loss of time to passengers. In an emergency, the safety device might also fail to act quickly enough to prevent the car from striking the bottom of the shaft, thus causing serious injury to passengers. Excessive speeds also cause greater wear and tear on equipment. For express elevators in high office buildings, greater speed can be advantageously employed, but the speed for express elevators should not exceed 600 ft. per minute.

Freight elevators should be limited to a speed of 250 ft. per minute. Where a speed governor is used in connection with the safety device, it should then be set to trip at a speed of 400 ft. per minute.

Operation. — Careful operation of elevators is essential to safety. A regular male operator, at least 21 years of

age, should be provided for both passenger and freight elevators. Accidents are just as likely to occur on a freight elevator, if not properly operated, as they are on a passenger elevator. This is especially true where freight elevators are not properly guarded. It is, therefore, important to assign a regular operator to each freight elevator. All other persons should be forbidden to operate an elevator. Where a freight elevator is not in continuous use, the operator can be employed at other duties near the shaftway.

A careful operator should be selected. Where possible, men of experience in the operation of elevators should be assigned to this work. In all cases, the employment of careless men and minors should be avoided. A new man should be thoroughly instructed before he is allowed to take charge.

Starters should, of course, be employed in large stores and office buildings to properly handle the traffic and prevent confusion and overcrowding.

Warning Signs. — In the case of freight elevators, conspicuous warning signs, such as "DANGER — EMPLOYEES ARE FORBIDDEN TO RIDE ON THIS ELEVATOR," should be placed over each entrance to the shaftway. These will serve to prevent unauthorized employees from using the elevator. Freight elevators should not be promiscuously used for the benefit of employees. Only a selected few should be allowed to ride upon them. Employees should use the stairways in going from one floor to another; they should not use the freight elevators.

A sign, "KEEP THIS GATE SHUT," should be placed on all gates which, when closed, do not automatically latch on the inside.

A capacity sign, indicating the maximum load in pounds which the car can safely carry, should be located in a conspicuous place within each freight car. Operators should be instructed not to allow this limit to be exceeded under any circumstances.

Tests. — A weekly inspection and test of safety devices

should be made by a competent mechanic. Where a speed governor is used, the safety device may be tested by simply tripping the governor as the car is descending near the bottom of the shaft. A careful examination of the governor mechanism, governor rope and sheaves should be made.

Safety devices, which are operated by a breaking cable mechanism, may be tested by blocking up the car. The car should be blocked at the landing in the basement, and not at the floors above. The car should then be gently raised by a jack or a pry-bar, until the cables become slack. The dogs or cams will then engage the guides and hold the car if the device works properly.

These testing operations should always be performed when the car is within a few feet of the bottom of the shaft, thus eliminating the possibility of a long fall. After testing, care should be taken to see that the cables follow in the proper grooves in the drum and sheaves as slack is taken up. Drums and sheaves should be provided with cable guards, preventing slack cables from running out of the grooves.

Inspection and Maintenance. — Each elevator should receive a frequent inspection at regular intervals by a competent engineer or mechanic. Too great importance cannot be attached to the value of thorough inspection and proper care of elevators. Defective and worn parts should be replaced. Proper lubrication of all machinery, including the cables, is essential. Machinery should not be allowed to become gummed with oil and dirt, nor corroded by moisture or fumes. All parts should be kept in perfect adjustment at all times.

ELEVATOR RULES

1. Employees should be forbidden to ride on freight elevators, unless their duties require it.
2. Never attempt to step or jump on or off a moving elevator.
3. Never use an elevator without permission from those in authority.
4. Always start and stop the car gradually, never suddenly.
5. Never use the automatic limit stops or locks to stop the car; always stop the car by hand.

6. Gates or doors should not be opened until the elevator has come to a full stop.

7. The car should not be started until the gate or door (unless automatic) is closed and latched.

8. Never start the car with passengers near the doorway.

9. Never attempt to speed the elevator either up or down.

10. Never allow the car to be overloaded.

11. Never step on, or walk across, folding hatch doors.

12. Hand trucks should always be locked on the platform, or held from movement by an employee, before the car is started.

13. Never start the car until sure that there are no projecting articles extending over the edge of the platform.

14. Keep gates shut at all times, when the entrance is not in use.

15. Always wait a sufficient length of time after signalling, in order that anyone who may be operating the elevator may respond.

16. Never wedge or prop up a gate, or tie it to an overhead beam. Gates should be in perfect working order at all times.

17. Keep your hands, feet, head and all other parts of the body, entirely within the car at all times, except when entering or leaving.

18. Never look or lean over a gate.

19. Never stand inside a gate, when the gate is closed.

20. Never allow material, tools or any other objects to fall into the shaft.

21. Never fool, or indulge in " horseplay," on or about an elevator.

22. Never pull hand trucks, or other material, backward upon an elevator.

23. Never go into a pit unless your duties require it. First, always notify the operator not to move the car.

24. Never ride on the cover of an elevator.

25. Never lean against a gate.

26. Never attempt to load or unload material until sure that the car is locked at the landing.

27. In case the safety device acts to stop the car, do not, under any circumstances, allow the passengers to attempt to get out of the car. Never try to start the car in either direction, while in this position.

28. In case the elevator cannot be moved either up or down, set the hand wheel, lever or rope, in the center position; do not try to start it again until it has been repaired.

29. Never reverse an operating lever or wheel, until the car has come to a full stop.

30. Be sure to center the hand-rope, wheel or lever of an electric elevator, when stopping; otherwise, the motor may be burned out.

31. Be sure to center the hand-rope of a steam elevator when stopping.

32. Be sure to pull the hand-rope of a belt-driven elevator as far as possible in starting. Use the check rope for stopping.

33. Creeping of a steam or belt-driven elevator signifies that the brake is not working properly, and it should be repaired before using.

34. In case a hydraulic elevator creeps, it signifies that the packing in the piston or valve is defective. This should be immediately repaired before the elevator is used again.

35. Never operate an elevator with a tight or loose hand-rope. See that adjustments are made by the proper person.

36. In case a steam elevator increases its speed in descending, it signifies that the piston, piston-valves or reversing-valves need repacking. The elevator should not be used until these have been repacked.

37. Make occasional tests of the speed governor and safety device.

38. Make frequent inspections of all cables for broken wires.

39. Make frequent inspections of the machinery, sheaves, limit stops, guides, springs, safety device and all other parts.

40. Repair defective flooring on the platform of the car, and on each floor at the entrances. Keep flooring in a safe condition.

41. If anything seems to be wrong with the elevator, do not try to operate it until the needed adjustments have been made.

42. Never attempt to adjust or tamper with any part of an elevator, unless you are familiar with the mechanism, and authorized to make repairs.

43. See that the car is kept locked whenever a man is in the pit, or on the overhead rigging, and do not, under any circumstances, allow anyone on the car while repairs are being made.

CHAPTER X

ELECTRICITY

Common Accidents. *—Electrical accidents are divided into two main groups; those caused by electrical flashes, and those caused by contact with live conductors.

Flashes. — Flashes or arcs occur upon breaking or momentarily short-circuiting a direct or alternating current. For example, a switch in a heavily loaded circuit may be opened by mistake; wires with deficient insulation may become crossed; an electrician working at a switchboard may allow his screw driver to slip on a contact. These flashes from high voltage conductors cause severe flesh burns and injuries to the eyes, which are very painful and dangerous. With a voltage much in excess of 15,000, a man seldom makes an actual contact with the conductor, because the current jumps over to his fingers, flexing them, and rendering it impossible for him to make the contact unless he is thrown upon it. It takes a person a perceptible length of time to approach a conductor, but the discharge is instantaneous. This discharge of current, which bridges the interval of space between the conductor and the victim, causes extensive surface burns and serious electrical shock.

When the discharge hits a man who is approaching a high voltage conductor, he falls as if shot. The discharge may carry a heavy current, though more frequently the man receives a small current, which is enough, however, to violently flex the muscles of his arm and legs, causing him to fall in a heap. Such precipitation assists in pre-

* The subject matter under this heading is an extract from a book on "Electrical Injuries" by Dr. C. A. Lauffer, Medical Director, Westinghouse Electric & Mfg. Co., published by John Wiley & Sons, New York.

venting him from receiving the more dangerous contact. If the man grasps a low voltage conductor, the electrical stimulation of his muscles causes his grip to tighten; and, if unassisted, he is often unable to release his hold.

Electrical flashes should be prevented and eliminated where possible. The careful handling of plugs and switches is imperative. During tests and repair work, the circuits should be open where practicable. Switches should be padlocked, and danger signs attached. The testing apparatus and immediate surroundings should be isolated by ropes. In repairing transmission lines and transformers, the lines should be thoroughly grounded at the point of repair on any side from which the power might be accidentally thrown on. Sleeves should be down, covering as much of the arms as possible. When working about electrical apparatus, the bare arms should not be exposed. The face should not be needlessly exposed in opening or closing a switch, especially on a line carrying a heavy load. Great caution should be observed in approaching live high voltage conductors. A safe distance should be maintained at all times. High voltage discharges have been known to jump some distance from the switchboard, enveloping a man in a flame, knocking him down in an unconscious condition, and severely burning him. High voltage should never be disregarded. On the contrary, being a dangerous factor, it should always receive a great deal of respect.

While the arcing distance for different voltages is given in every standard electrical handbook, there are surges in high voltage, rendering it at times abnormal. Consequently, there may be arcing to a greater distance than is ordinarily anticipated. When the air resistance is once broken down, the flaming arc may carry considerable current to anyone who has approached too near.

Although electrical flashes are of momentary duration, the heat developed in an instant of time is often very great. This intense heat produces painful burns on the unprotected skin and eyes.

High voltage flashes cause destruction of all the layers of the skin over large areas.

Great mental excitation, and even transient mania, are sometimes observed in these cases. On the contrary, some victims are relaxed, unconscious, and asphyxiated, requiring immediate resuscitation by artificial respiration.

Contact Injuries. — The two types of contact injuries are shocks and burns. The passage of an electric current through the body may cause a momentary unpleasantness; or the retention of the victim within the circuit, rendering him unable to release himself; or a suspension of consciousness during which he falls, but again revives if the fall does not kill him; or a suspension of animation which requires immediate artificial respiration.

There is a wide variety of external and individual conditions that influence the extent and character of electrical injuries. Statistics thus often appear inconsistent. Individual susceptibility is an important element. Even the emotions have an important effect. Cases have been reported where a lineman has died of fright on touching a high voltage line which was not charged at all. In certain instances, only 110 volts may prove fatal. Again, under certain conditions, a man may receive 15,000 volts with impunity.

Other things being equal, the higher the voltage, the greater will be the electrical current through the body. The greater the number of points of contact, and the longer the duration, the greater will be the danger to life. The human body is a relatively poor conductor. Its high resistance greatly reduces the amperage of the current. It is usually a shunted current which the victim receives, — a leakage from the line, and not the full current, as many believe.

Wiring. — All electrical wires should be enclosed in conduits of metal pipe. No open wiring should be allowed. If wires are not run in metal conduits, they should be encased in approved mouldings. Wires should not be allowed

in concealed work. They should not be used in places exposed to dampness, unless they are covered with approved waterproof insulating material. Wires should never be buried in plaster, nor attached to wood by staples. Neither should they be supported upon wood or metal. Where wires are not run in a metal conduit, or an approved moulding, they should at least be supported upon noncombustible insulators. A metal pipe conduit, or wooden moulding, does not insulate the wires, but it serves to protect them from dampness, acids, alkalies, blows, abrasion and any other force which may cause the insulation to become defective. The metal pipe conduit best protects the wires from physical or chemical injury.

Wires should be completely insulated at all joints or connections. All joints should be safely enclosed in junction boxes. Open wiring is dangerous on account of the fact that it may either cause accidents or fires. It is especially dangerous if the floors are damp or the insulation defective. Excess current may break down the insulation protecting the wires. Especially dangerous cables and apparatus should be painted red, and warning signs and notices placed at all dangerous points. All dangerous parts should be guarded against accidental contact.

The greatest care should be observed when working on or about any kind of electrical apparatus. No one except the electricians should be allowed to touch electrical apparatus or wires of any kind. Care should be taken to obtain proper insulation from the ground. Wires should never be worked upon when standing or sitting in a wet place, nor when standing upon metal work. No circuit should be worked upon until the power has been shut off, and the switch padlocked. If it becomes absolutely necessary to work upon a live circuit, care should be taken to work upon but one wire at a time, and to use only one hand so far as possible. Rubber gloves should always be worn when working upon live circuits, and when working upon high tension circuits over 220 volts, which are known

or believed to be dead. Employers should provide standard tested rubber gloves for the electricians. These gloves should be kept in good condition, and should always be inspected before use.

Portable towers, for use in wiring on street railways, should be provided with a wooden guard railing and toeboard about the top to prevent men or tools from falling. Linemen are always subject to severe falls caused by electrical shock or by slipping. Linemen should always have assistants with them, when engaged in this kind of work, to render aid in case of an emergency. Electricians, working upon telephone or telegraph lines, should wear safety belts. The belts should be extra strong, and provided with suitable sockets for linemen's tools. These belts should always be carefully inspected before use. The handles of uninsulated tools should be wound with insulating tape to lessen the danger of shock in case of accidental contact with a live conductor. Wooden clamps, or tongs, about one yard in length should be used for handling live wires when down. Linemen should also be provided with thick rubber shields which may be clamped over high tension wires when working on poles.

Transformers. — Where transformers are within main buildings, they should be isolated in separate, enclosed, fireproof vaults, ventilated with a chimney or a flue. These rooms should be kept locked. A prominent danger sign should be placed on the door, forbidding employees to enter the room. The floors in transformer rooms should always be free from moisture. They should be of non-conducting material, and covered with thick rubber mats. It is preferable to isolate the transformers in a separate locked building, built for this purpose. There is then less danger of employees entering the room, if the door is left unlocked through carelessness. Where transformers are located on poles, railed platforms should be provided, which will allow a safe and easy inspection. The transformers and platform should be located at such height that no access

can be obtained to them except by a ladder. This will keep away children and others who have no right to go there. Prominent danger signs should also be painted on the cases of transformers.

All transformer cases should be thoroughly grounded. Connections should be completely insulated. Connections to the ground should be so constructed that they cannot be broken by the removal of the fuse box or other parts of the case. All holes in transformer cases, through which high voltage conductors pass, should be bushed with thick insulation. All connections of the high voltage wires with the transformers should be completely insulated, and so protected that it will be impossible to accidentally touch them. Switches for shutting off both the high and low voltage currents of transformers, should be operated from the outside of the building. All metal objects within transformer rooms should be effectively grounded.

Transformers and connections should receive periodical examinations. Leads which have been exposed to the weather for long periods often become stripped of insulation. They may thus come in contact with the case.

Generators and Motors. — Generators and motors should be located in dry places. They should be mounted at least 8″ above the floor on dry wood. Pans should be placed underneath to catch all oil drippings. Above 250 volts, the frames, and other non-conducting metallic parts, should be effectively grounded. Under 250 volts, the frames should be insulated from the ground. In any case, the flooring about motors and generators should be of some insulating material, covered with rubber mats. Generators and motors should also be guarded with substantial wooden railings, or railings which are covered with insulating material. (Fig. 23.) Rubber mats should never be allowed to become wet or covered with oil. Wooden mats, with no metal parts of any kind, are more substantial.

Where generators and motors are placed near walls, the belt side should be placed next to the wall. There is

then less danger of anyone being caught by the belt when working on or about the machine. The belts of all motors

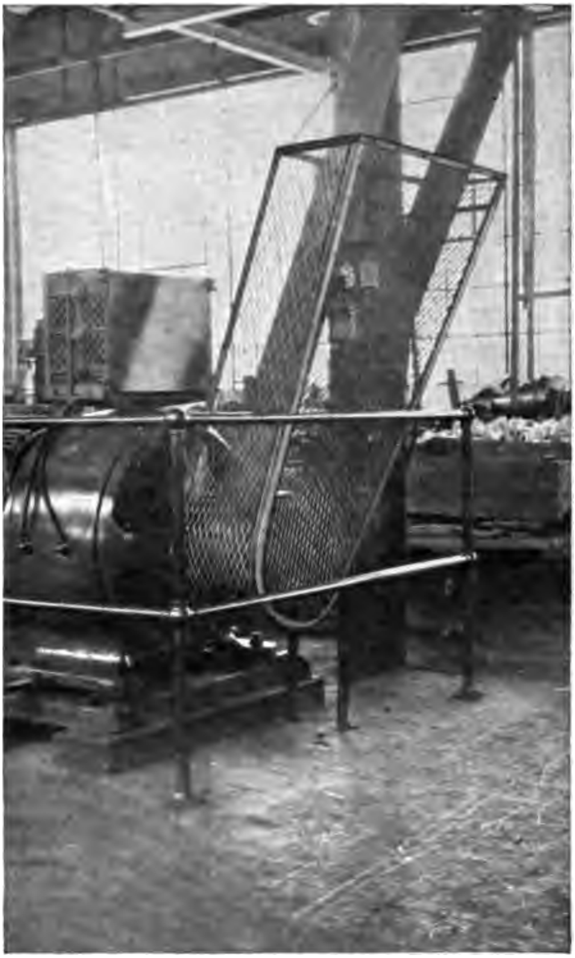


FIG. 23
Properly guarded motor. Belt guard of expanded metal and angle iron in addition to pipe railing.
Courtesy Goulds Manufacturing Company.

and generators should be guarded to a height of 6 feet from the floor or platform level. All generators and motors

should be protected by automatic circuit breakers. They should be covered with waterproof hoods when not in use. All dangerous exposed parts of generators and motors should be covered with metal guards. Generators and motors should be controlled by multi-pole switches. Starting switches should be provided with locks, so that they may be locked on or off position. Where possible, non-magnetic tools and oil cans should be used in working about motors and generators. Magnetic objects are likely to be drawn into the machine.

Switchboards. — Switchboards should be located in dry places. The floor at both the front and rear should be covered with thick rubber matting, or some other insulating material. The rear of all switchboards should be entirely fenced off at both ends between the switchboard and the wall, or guarded by a fencing about the rear. (Fig. 24.) If near a wall, the switchboard should be located at least 3½ feet from it, in order to leave sufficient room for examinations and repairs. The entrances to the rear of all switchboards should be kept locked. A space of 18″ should be left between the floor and the bottom of the board, to prevent the accumulation of any oily waste and rubbish, which might otherwise escape notice. The switchboard should be equipped with a master switch for rendering the board "dead." The switchboard should be dead before any work or repairs are made upon it.

Switches. — The service wires to any building should be provided with a service switch, which will shut off the current, preventing it from entering the building. The switch should be located on the outside of the building, or outside the transformer house.

Switches should be mounted upon non-conductible bases and enclosed in metal boxes or wire mesh enclosures, which can be locked. (Fig. 25.) Switches should be located in dry places. All switches should be of the double or multi-pole type. The carrying capacity should be sufficient to prevent heating. Switches should never be designed to

close by gravity; otherwise, they may be accidently closed by vibration, by being hit, or by other causes. Switches should be so designed that they may be locked on or off

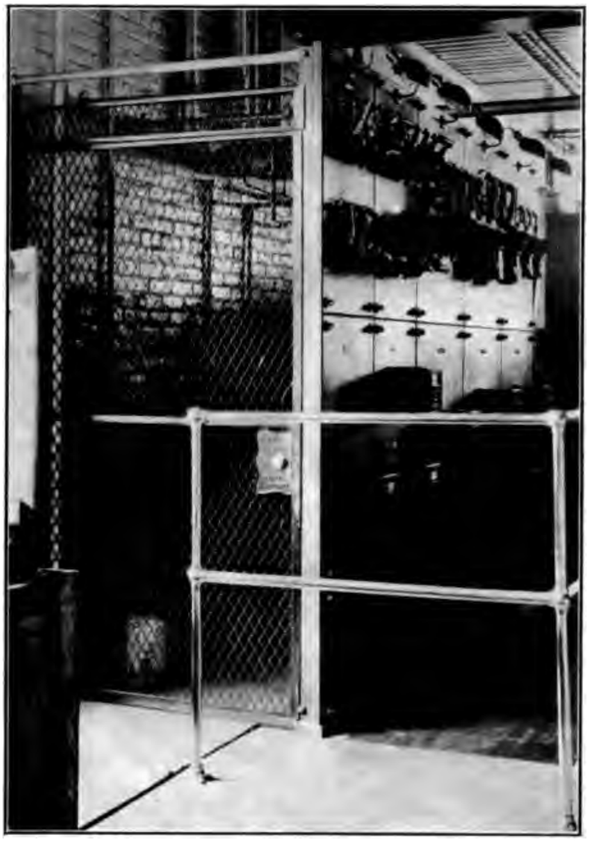


FIG. 24
Properly protected switchboard. Locked door at each end in rear, railing in front, and rubber mats both front and rear.
Courtesy Chalmers Knitting Company.

position. This will prevent anyone from accidentally brushing against them, making or breaking the circuit. It will also prevent anyone from causing an accident by tampering with them. Oil switches, or enclosed switches, should be

used where a spark might cause a fire or an explosion. Switches should not be allowed to become loose or defective. They should never be placed over wet floors, metal plates, behind belts, or in any other dangerous and inaccessible places.

Fig. 25
Enclosed locked switch.
Courtesy Detroit Fuse & Mfg. Co.

Circuit Breakers. — A circuit breaker is a device for breaking the connection between the generator or motor, and the circuit. It serves the same purpose as a fuse, but it is more sensitive, operating instantly where there is an excessive current. A fuse requires time to be heated sufficiently before the circuit is broken. The breaker operates upon the principle of an electro-magnet. It is so adjusted that when the magnet is excited above a given maximum, a piece of iron is attracted to it. This piece is connected to a trigger which releases a spring, forcing the switch open.

There are several different kinds of circuit breakers which are used for various purposes.

The "overload" breaker protects the motor, and motor driven machine, from being unduly overloaded from any cause. Overload may be caused by too rapid starting of the motor, by working the motor driven machine beyond its capacity, by faulty adjustments in the driven machine, by foreign bodies in its working parts, or from a variety of similar reasons.

The "no voltage" circuit breaker is used for motor protection, where the source of current supply is subject to occasional interruption. If the power supply to a direct current motor is interrupted long enough to permit the motor to slow down, or stop entirely, and is then restored, with the motor starter in the running position, the motor will receive a current much in excess of its capacity. This will suddenly start the machinery, very likely resulting in an accident. In any case, the motor

and machinery may be ruined. The "no voltage" breaker prevents this by automatically disconnecting the motor from the line when, after the cessation or interruption of the power supply, the speed of the motor suddenly falls below normal. These circuit breakers are so arranged that all the switches must be opened before the machinery can again be started.

The "shunt trip" circuit breaker is used on cranes and hoists, to prevent overwinding, and in other similar instances where it is desired to limit the distance of travel of any object. They are of value in textile mills using individual motor drive. Where each motor is protected with a "shunt trip" breaker, the possibility of injury to employees is greatly diminished, as a ready means is afforded to instantly cut off the power from any given machine.

The "time limit" circuit breaker protects motors from undue continuance of heavy starting currents, such as might result from attempts to start motors which are too heavily loaded, or with one phase disconnected. This breaker is designed to open on long continued moderate overloads, although it will, nevertheless, permit the passage of heavier currents for a sufficient period in starting, provided load conditions are normal. Obviously, with the above arrangement, the sensitiveness of the circuit breaker to overloads is limited by the requirements for starting. Where motors are employed in connection with delicate mechanical operations, it is sometimes desirable to make the breaker responsive to even the slightest overloads. For such contingencies, a special form of circuit breaker may be used, in which a single multi-polar switch is under the control of two sets of overload coils, one set being in circuit on the starting side, and the other on the running side. As the maximum instantaneous value of the starting current is practically independent of the load, the only protection possible during the starting period is not the limiting of the starting current, but the prevention of its

undue continuance. "Time limit" circuit breakers on the starting side are, therefore, essential adjuncts of the overload features. They are also desirable on the running side unless the highest degree of sensitiveness to overload is required.

Circuit breakers can, in fact, be advantageously adapted to practically any kind of service. They act as a valuable safeguard against serious electrical variations in the circuit and the unexpected starting of machinery. Certain types of circuit breakers have the functions of the circuit breaker and the switch combined in a single instrument. This type of circuit breaker is particularly adapted to the protection of motors and employees whose management is likely to be in the hands of those who are ignorant, careless, or lacking in a proper knowledge of electricity. Often, a workman closes a circuit breaker before the switches are opened, causing an accident and ruining machinery. With these types of circuit breakers it is impossible to close the circuit during the continuance of the overload. Should an overload arise, through a closed switch which should have been opened, the switch arm will instantly be released. The circuit will thus remain broken regardless of the amount of pressure which may be exerted upon the handle. These circuit breakers can be used on either two or three wire systems with an equally advantageous effect. They have the advantage of protecting both the machinery and the workmen.

Fuses. — All fuses and cut-outs should be marked with their safe carrying capacity in amperes. They should be enclosed in metal boxes which are readily accessible. Fuse boxes should be kept closed. The plug should be of moisture proof and non-conducting material, so constructed that an arc cannot be maintained across its terminals by the fusing of the metal. Fuses should be placed at every point where a change is made in the size of the wire, unless the one in the larger wire will protect the smaller. Extra fuses should be kept in a handy place where they can be

immediately used to replace burnt fuses. In no case should a fuse ever be bridged with wire. This would leave the circuit without a safety device, endangering life and property.

Arc Lamps. — All exposed parts of arc lamps should be carefully insulated from the circuit. Each lamp should be provided with a hand switch, located at a convenient place away from the lamp, and also an automatic switch which will shunt the current in case the carbon fails to feed properly. Stops should be provided to prevent the carbons from falling out, in case the lamp becomes loose. Lamps should be provided with a lowering device, which will automatically shunt the current when they are lowered for cleaning and trimming. This device eliminates the necessity of lamp trimmers climbing on cranes or crane runways, or on other dangerous overhead places. Each lamp should be provided with a wire-glass globe, fastened upon a closed base. This will hold the glass in case of breakage. Broken or cracked glass globes should be immediately replaced. Lamps should be equipped with approved spark arresters, where inflammable material is used or stored, to retain any sparks of molten copper or heated carbon. Globes should be cleaned every time the lamp is trimmed. If a lowering device is not installed, suitable platforms should be provided for lamp trimmers.

Incandescent Lamps. — Where incandescent lamps are used in a room where volatile or explosive fluids are confined, they should be completely encased in vapor-proof globes of strong glass. Connections should be carefully made, and conductors insulated at all points. No switches, resistances, circuit breakers, or other electrical appliances should be located in the room. Warning signs should be conspicuously displayed at points where there is special danger of accident. All dangerous places should be guarded. Portable lamps should be protected with suitable basket guards. This type of guard protects, to some extent, the lamp from being broken. The handle should be of wood, and there should be no metal parts

which can cause a short circuit, giving a shock to whomsoever may be holding the lamp.

Storage and Primary Batteries. — When the current for light and power is taken from secondary or primary batteries, the same precautions should be observed as with similar apparatus fed from generators or motors developing the same difference of potential. All secondary batteries should be mounted upon non-combustible insulators.

ELECTRICAL RULES

1. All persons, except electricians, should be forbidden to handle or touch electrical apparatus of any kind.

2. Be cautious and alert at all times, and under all conditions.

3. Never fool or experiment with electricity in any way.

4. Do not take any unnecessary risks, even though the voltage is low. Avoid even slight shocks when in high places.

5. If you see any person handling electrical apparatus who has no right to do so, stop him at once, and report the matter to the foreman.

6. If you see any electrical equipment in an unsafe condition, or being improperly operated, correct the condition, or report the matter to the foreman.

7. In handling any circuit known to be "alive," wherever possible, use only one hand. It is best to keep the other hand behind the back. The most dangerous shocks are those from hand to hand.

8. Never attempt to extinguish a fire on or about electrical apparatus with water. Water is a conductor of electricity. Use a powder extinguisher, blankets or sand.

9. Never look at an intense arc without adequate eye protection, such as heavy blue and red glasses. Often, intense pain results from exposure of the delicate nerves of the eye to the light of an electric arc. As this pain does not often manifest itself until several hours afterwards, you should immediately see a doctor, if you have so exposed your eyes.

10. Never handle electric wires while standing or sitting in a wet place. Use care to obtain insulation from the ground.

11. Never do any work on equipment, where its operation might injure you, until the power is turned off, and you have attached a safety padlock to the switch, bearing your name or number, so that the equipment cannot be operated until you have released it.

12. Never close a switch without full knowledge concerning the circuit, and why the switch was opened.

13. The insulation on electric wires cannot be depended upon to protect you from shock. So far as possible, avoid working on any "live" circuits.

14. So far as possible, treat all circuits as though they were "alive," even though you know or believe them to be dead. None but experienced men should work on lamp circuits. First, cut the lamp out of the circuit by means of the switch.

15. Switches, motors, generators, circuit-breakers, or other electrical ap-

paratus capable of causing a spark, should never be placed in rooms where volatile or inflammable material is confined.

16. Linemen should always wear safety belts when working overhead.

17. Rubber gloves should be provided for electricians. They should be kept in good condition, and always inspected before use. They should be worn by electricians when working about " live wires," or on high tension lines.

18. When working on high tension lines, never fail to keep an assistant near you to render aid in case of emergency.

19. Rubber mats, or other non-conducting treads, should be placed about all switchboards, motors, generators, transformers, and all high tension apparatus.

20. Never allow floors about any electrical apparatus to become wet.

21. Never bridge a fuse with wire.

22. See that all fuses are enclosed, that fuse boxes are kept shut, and that extra fuses are kept near the fuse box.

23. No examination, repairs or alterations necessitating the handling of machines, wires, cables or other electrical apparatus under high voltage, should be made when the circuit is closed, unless absolutely necessary; and then the work should be done only by an expert electrician.

24. Sleeves should not be rolled up, exposing the arms, when working about electrical apparatus.

25. Power feeders, above 250 volts, should be handled with great care. Carelessness might cause a fatal accident. Such systems, when " alive," should never be worked upon out of doors during rainy or damp weather, nor at any time, except with the approval of the Chief Electrician.

26. Remember that, under certain conditions, it is possible to receive a fatal shock from a 115-volt circuit.

27. When working upon "alive" circuits, care should be taken to work upon but one wire at a time. All parts of the body should be properly insulated from the ground and other wires of the circuit. Insulate each joint as it is made, before starting on another wire. Be sure you are properly protected from falling from the scaffold, crane, etc., in case of shock. Careless haste, in working on "alive" circuits, is the cause of most electrical accidents.

28. The handles of all electrical tools should be properly taped to assist in preventing short circuits across them.

29. Before using hand lamps in a room where volatile or inflammable substances are used or stored, be sure that they are covered with wire guards. See that the wires and connections are properly insulated.

30. If anyone should come in contact with "live" wires or cables, and be unable to release his grasp on the wires, do not attempt to pull him off with bare hands. Shut off the current, if possible, and protect the hands with rubber gloves; or if they are not to be had, use thick folds of cloth to cover the hands, before attempting to release the victim. If the wires are lying directly on top of the victim, use a dry stick to remove them.

31. Flexible cord for lamps should not be tied on metal rods or nails, nor allowed to come in contact with water or oil.

32. There are many special conditions which make electrical work dangerous. Even telephone or signal wires may become crossed with high tension wires, becoming dangerously charged. Competent electricians are always careful and alert.

CHAPTER XI

TRANSMISSION

Shafting. — Shafting within 7 feet of a floor or platform should be completely encased with a cylindrical sheet metal covering. (Fig. 26.) In place of this, wire mesh or wood may be used for enclosure. All dead ends of shafting should be similarly guarded. Although bare shafting appears perfectly harmless, nevertheless it frequently causes a fatal accident. Bare revolving shafting is capable of engaging loose or torn clothing and quickly winding it upon itself, whirling a victim to death. Shafting is especially apt to catch loose clothing if it is marred or bruised, thus forming a rough surface. Long flowing neckties, unbuttoned jumpers, loose aprons and strings, loose suspender straps, and the loose hair of women are frequently caught by revolving shafting with fatal results.

The cylindrical sheet metal covering shown in the figure consists of two sections, so that it may be easily placed about shafting. This cover remains loose on the shaft, affording absolute protection. Ordinarily, it revolves with the shafting, but as soon as pressure is applied its motion is immediately arrested. Spirally wound paper cylinders or mailing tubes may be used in place of a sheet metal covering. After being slit longitudinally they can be easily slipped upon shafting and then fastened by gluing the parts together along the slit with a strip of tape.

Keys. — All protruding keys should be completely covered, including keys on power working machines. Unused parts of keyways should be filled flush with the surface of the shafting with tallow or wax.

Fig. 26

Sheet metal casing for shafting.

Courtesy Safety Power Transmission Co., Brooklyn, N. Y.

Couplings. — All couplings should be of a safety type. Old style couplings, containing protruding nuts and bolt-ends, should be entirely eliminated. If used, there is always danger that they may catch the clothing of a careless workman, thus causing an injury.

FIG. 27
"Bull-dog" shaft coupling, an improved safety type.
Courtesy Automatic Shaft Coupling Co.

Fig. 27 shows a view of the latest and by far the best type of safety coupling on the market. It consists of a metal cylinder having two interior eccentric chambers which are equipped with steel rollers held in place by stiff wire brackets. The coupling automatically locks itself as it is turned on the shaft, or as the shaft turns; the greater the power being transmitted, the tighter the coupling grips the shaft. There are no bolts, screws or keys. A hole is provided in the middle of the coupling in which a steel pin or handle may be inserted for loosening or tightening the coupling when the shafting is at rest. The coupling grips the shaft by the wedging action of the rollers as power is applied. The coupling is a single unit. It has a positive grip, slipping being a mechanical impossibility. It insures perfect alignment. A reducing coupling can be used for shafts of different diameters. It entirely overcomes the danger of breakage from longitudinal strain upon shafting which may be caused by contraction or expansion. It requires only the bare hands for attaching it to shafting, and can be readily removed after long continued use. There are no wearing parts which require renewals. Oil and moisture cannot affect it, and no dirt or grit can enter. It is of exceptional value in the prevention of accidents.

A safety set collar is also on the market which is similar to this coupling, no set screws or tools being needed to attach it.

This same invention has also been successfully applied to pulley bushings. Pulleys and collars of this type have all the advantages of the safety coupling above described.

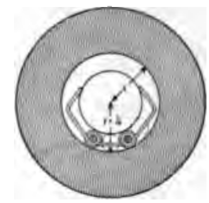


FIG. 28
Sectional view of "Bull-dog" shaft coupling.
Courtesy Automatic Shaft Coupling Co.

Set Screws. — All protruding set screws, on shafting, countershafting, and revolving parts of machinery, should be replaced with those of the headless type. The day of the protruding set screw is passing. No responsible employer will permit them in his factory. Quite frequently an employee, after making repairs or alterations, will place a protruding set screw in a collar, instead of a headless set screw. This evil may be eliminated by allowing no old style set screws to be issued from the stock room. Fig. 29 shows the headless type of set screw with a key for screwing it into the collar. These are sold in all sizes,

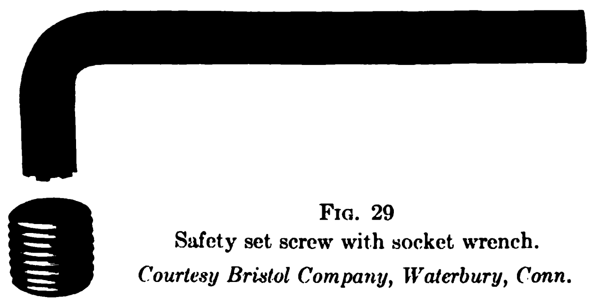


FIG. 29
Safety set screw with socket wrench.
Courtesy Bristol Company, Waterbury, Conn.

and there are a number of other similar types on the market. This type of set screw does not project beyond the face of the collar. It is, therefore, unable to catch loose clothing. The headless type of set screw is preferable to the countersunk type. The hole in the headless set screw may be filled in with wax or paraffin to prevent rusting. Old style couplings and protruding set screws have been the direct cause of an enormous number of fatal accidents, and they are a constant menace to life and limb.

Friction Clutches. — When within 8 feet of a floor or platform, friction clutches should be completely housed with metal or wire mesh hoods. Exposed friction clutches of power working machines are especially hazardous. The

FIG. 30

Safety, multiple disc, solid friction clutch. The toggle mechanism is completely enclosed and the clutch is practically dust-proof. This type of clutch is made for use with a pulley on sleeve or as a cut-off coupling. This view shows clutch completely assembled.

Courtesy Dodge Sales & Engineering Co.

most modern form of friction clutch is now provided with a metal enclosure which guards dangerous revolving parts.

FIG. 31

This is an unassembled view of safety friction clutch shown in Fig. 30.

Courtesy Dodge Sales & Engineering Co.

Bearings. — Bearings should never be covered, but should be clearly exposed to view at all times. They should be of the self-oiling variety, so that there will be no occasion for the oiler to go near them when the shafting is in

motion. Ring oiling bearings are the best type. They are the safest, most efficient, convenient, and reliable. The rings should be made of tempered spring steel, and should perfectly retain their shape. The rings should revolve with the shaft, constantly feeding oil to the bearing in regular quantities. Permanent devices are used to return the surplus oil to the reservoir, thus using the oil over and over again, and insuring a steady supply. This means a great saving in oil consumption in a large factory. The bottom of the oil reservoir should be flat. This prevents the bearing overturning when out of the frame, and dispenses with the depressions for oil rings used in other types of ring oiling bearings. Depressions are apt to fill with sediment and prevent the free working of the rings. With a flat bottom the oil is of the same depth for the full length of the reservoir. A heavy oil should never be used as it is likely to clog and prevent the free rotation of the ring. This is especially true when a chain is used in lieu of a ring. The ring oiler is preferable to the chain oiler, or to the plain bearing with grease cups.

Shafting should be frequently inspected to make sure that it runs true, that the hangers are not working loose, and that the bearings are receiving proper lubrication. Hangers should not be spaced too far apart, but should be spaced according to the thickness of the shaft, to its weight, and to the stresses to which it will be subjected. No set rule for spacing bearings can be used, as there are several factors to be taken into consideration in each case.

Pulleys. — Pulleys should be spaced at a slightly greater distance from bearings or hangers, or other pulleys (except tight and loose pulleys), than the width of the belt, so that in case the belt slips the pulley, it will not become wedged between the hanger and the pulley, or between two pulleys, thus pulling down the line shafting. If it is impracticable to space pulleys farther from a hanger, or another pulley, than the width of the belt, the intervening space should be guarded in such a way that it will be im-

possible for the belting to become wedged, should it slip the pulley. This may be done by placing a spool, 4" larger in diameter than the pulley, on the side of the pulley adjacent to a hanger or another pulley.

Pulleys, carrying large, high-speed, transmission belting, and also friction clutches, within 2 feet of a hanger, should be protected on the nearest side by an angle iron and wire mesh guard substantially fastened to the wall or ceiling.

It is often desirable to cover arms of pulleys and balance wheels of power working machines with an inserted fiber or sheet metal disc.

Pulleys on line shafting within 7 feet of the floor or platform should be guarded on the under side.

Pulleys should be a little wider than the width of the belt. A frequent inspection of pulleys should be made to discover cracks which are likely to develop in the arms and rims. When a crack occurs, a piece of the rim may be thrown out by centrifugal force, causing a serious accident. In the course of inspection, the pulleys should be hammer tested to discover cracks, and if found, the pulleys should be immediately replaced. Pulleys with pieces missing from their arms or rims should never be used. Faces of pulleys should be smooth and even.

Counterweights of idler pulleys should be guarded or enclosed.

Belting. — Vertical or inclined transmission belting should be entirely enclosed to a height of 6 feet. Horizontal belting, within 7 feet of a floor or platform, should be protected underneath and on the sides with a substantial suspended guard. Belts and pulleys which drive power working machines should be protected with guards of wire mesh, sheet metal, or perforated metal on frames of angle iron.

The best belts are made from oak tanned leather, curried with cod oil and tallow. The flesh side of the belt should not be run on the face of the pulley. The wear should come on the grain side. The tensile strength

of this side is weaker, but the grain side of the belt will wear better. If the grain is finally worn off, the belt will

FIG. 32
Sheet metal guards applied to vertical belts of speeders.
Courtesy Phoenix Underwear Company.

not have a tendency to crack on the grain side. Belts should be cleaned and dressed at least twice a year.

Belts should preferably be fastened together by splicing and cementing, rather than by lacing. Endless belts are preferable from the standpoint of durability and safety. Metal belt hooks, or metal clamps of any kind, should not be used for fastening. If lacing is resorted to, rawhide or wire should be used. The holes should be made

FIG. 33
Woven wire guards applied to vertical belts of spinning frames. The framework of guards consists of iron rods.

Courtesy Norwich Wire Basket Co., Norwich, N. Y.

with an oval punch, with the longer diameter parallel to the sides of the belt. The edge of the holes should not be nearer than $\frac{1}{2}''$ from the sides, nor less than $1''$ from the ends of the belt. On large belts, these distances should be even greater. At least two rows of holes should be punched and staggered. The second row should not be less than $1\frac{3}{4}''$ from the end of the belt. The lacing should be started at the center, care being taken to keep the ends

of the belt exactly in line. Both sides should be laced with equal tightness. The lacing should not be crossed on the side that runs next to the face of the pulley. Loose

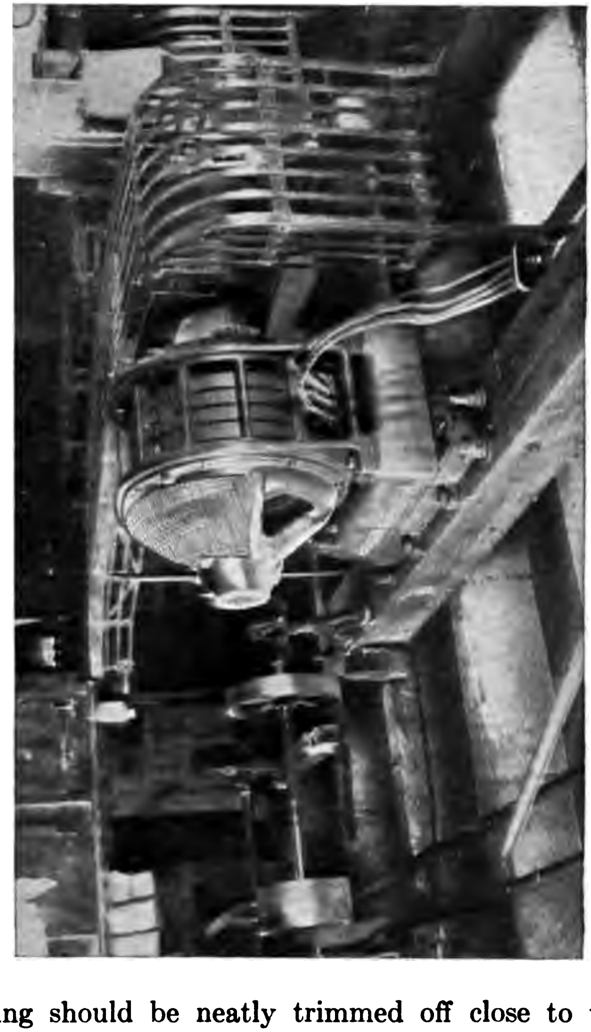


Fig. 34

Overhead, horizontal, transmission belt guard of strip iron and angle iron substantially suspended from floor beams above. Note wire mesh guard for lower opening in frame of motor.

Courtesy Phoenix Underwear Company.

ends of belting should be neatly trimmed off close to the belt. Belts should never be spliced or tightened while any part of the machinery to which they are attached is in motion. If belts are to be made endless, they should

be put on with the ends drawn together by clamps. If the belt is made endless in the factory, it should never be run upon the pulleys, as the irregular strain may spring

FIG. 35
Large, horizontal, transmission belt guarded by a standard double-railed railing 3½ feet high, placed 18 inches from moving parts.
Courtesy Niagara Paper Mills.

the belt. One shaft should be lifted out, the belt being placed on the two pulleys, and the shaft then forced back into place.

Belts should never be unduly tight as they will cause broken pulleys, hot boxes, or result in the breaking of the

belt itself. They should be sufficiently slack to move with a loose undulating vibration on the returning side. No more strain should be imposed than is necessary to transmit the power. There should be a gentle sag in the belt when it is in motion, and the distance between shafting should be enough to allow such a sag. A good average is 15 feet for narrow belts, 25 feet for larger belts, and 25 to 30 feet for main belts on very large pulleys. If too great a distance is attempted, the belt will have an unsteady flapping motion, which will quickly destroy both belt and machinery, causing serious injury to nearby workmen.

If possible to avoid it, connected shafts should not be placed one directly over the other. In such a case, the belt would have to be kept very tight to perform the work. It is desirable to have the belting tilt at a considerable angle from the vertical, at least 45 degrees where possible. It is also advisable to so locate shafting and machinery that the belts will run off a shaft in opposite directions. This relieves the bearings from undue friction which would result if the belts should all pull one way on the shaft. Belts pulling in opposite directions should be placed as near each other as practicable. Belts pulling in the same direction should be widely separated. If possible, machinery should be so placed that the direction of the belt motion will be from the top of the driving to the top of the driven pulley. In this case, the sag will increase the arc of contact. The motion of driving should run with, and not against, the lap of the belts.

Where necessary, idler pulleys should be applied to the slack side of the belting near the smaller pulley.

Ordinarily, it is better to gear a mill with small belts and pulleys running at high speeds, rather than with large belts and pulleys running at slow speeds. A mill thus geared is usually more efficient, and the operating cost is less.

Belts should be protected against water, exhaust steam, and moisture. Otherwise, waterproof dressing should be

applied. Oil should not be allowed to drip on belts, as it destroys the leather. Belting cannot safely stand a higher temperature than 130 degrees F.

Belts usually weaken and break near the lacing. They should be periodically inspected. If defects are found, the belts should be at once repaired or replaced.

RULES FOR BELTING

1. Never crawl through, over or under a belt.
2. Never shift a belt by hand. See that a suitable, permanent belt shifter is installed.
3. Never attempt to repair, dress or lace a belt, while the machinery is in motion. First stop the machinery.
4. Never grasp belts to start or stop a machine.
5. Never allow a belt to rest on a revolving shaft. The belt may become tangled with someone or something, causing a serious accident. A belt perch should be provided to receive the belt, when it is removed from the pulley.
6. Never place a pulley nearer to a shaft hanger, or another pulley, than by a distance a little greater than the width of the belt.
7. If it is impracticable to do this, place a guard in the intervening space between the pulleys, or pulley and hanger, to prevent the belt from becoming wedged and tearing down the shafting, in case it springs off the pulley.
8. When it becomes necessary to place a belt upon an overhead pulley, use a substantial belt pole provided with a belt perch or hook at the end. The pole should be nearly the length of the distance between the shaft and the floor. This will necessitate keeping the pole at the side of the workman, instead of in front of him, which is dangerous. A short belt pole is a source of danger.
9. When the belt is too large to be placed upon an overhead pulley by a hooked belt pole, it becomes necessary to place it on by hand, while standing on a ladder. The ladder should be placed on the side of the pulley opposite the belt. This position facilitates the operation, and decreases the danger of the workman being caught and drawn over the shaft. The operation is at best a dangerous one, and should be avoided wherever possible.
10. In unshipping belts, a belt should always be thrown off the "running off" side of the driving, and not of the driven pulley.
11. Never run belts under excessive tension, nor so loose that they flap. Horizontal, or slightly inclined belting, should have a smooth undulating motion.
12. Make frequent inspections of all belting, especially near the lacing, as this part of the belt is most susceptible to wear, and most likely to crack at this point.

Gears. — All gears should be completely encased, or otherwise guarded, regardless of their size or location in the factory. It is just as important to cover overhead gears as it is to remove protruding set screws in overhead

shafting. Workmen are apt to climb upon machines or stepladders to make repairs or oil machinery in motion, and then be caught in exposed gearing.

If gears are guarded with strap iron, it should conform to the shape of the gears, extending completely around the exposed parts. The strap iron should extend over on the edges to form side flanges, thus enclosing the gears to the roots of the teeth. Gear guards should be removable to facilitate oiling and cleaning, but care should be taken to replace the guards before the machine is again placed in operation.

Ropes, Chains, and Sprockets. — The standards used in guarding belts should also be applied to the guarding of ropes.

Care should be taken to completely guard all chains and sprockets on power working machines.

Power Control. — Some means should be provided for quickly shutting off the power in each room or department. This may take the form of an automatic engine stop with push buttons located in different parts of the factory, a switch, a tight and loose pulley, a friction clutch, or a belt shifter and idler. An electric push button system to signal the engineer to stop the engine in an emergency may also be used.

Switches or push buttons, placed about the factory, may be electrically connected to a motor stop system, in order that a motor may be quickly stopped in case of accident.

Where tight and loose pulleys are used, the loose pulley should be so mounted that it would be impossible for it to engage the shaft or produce side friction on the adjacent rim of the tight pulley, thus accidentally starting the machinery.

A belt shifter and idler is shown in Fig. 36. This is a device for shifting a belt from a driving pulley to the roller idler, where it rests until again required for the transmission of power. The idler consists of a fixed hanger, essentially one piece, having a removable segment or center

piece, so opening that the hanger may be placed around a shaft. The hanger has radial elongated slots for the reception of a circular series of belt sustaining rollers. The radial slots permit a limited adjustment of the rollers to conform to pulleys, also enabling the rollers to be secured in different slots, or adjusted to conform to the position or angle of the belt. The rollers are journaled upon studs, and are secured to the hanger by lock nuts. The rolls are slightly tapered toward the pulley to facilitate the sliding action of the belt to and from the pulley. The number of rollers required depends upon the diameter of the pulley.

The shifter is a separate segment bolted to the hanger at the required angle to accomplish its purpose. It consists of two studs on rods, two sleeves sliding lengthwise on the rods, a pair of adjustable belt shifting arms, and a shifting lever.

This device takes the place of, and is an important improvement over, the tight and loose pulley. When the belt is shifted on the idler, it remains stationary. This not only saves a large amount of wear, where the belt would be constantly running on the loose pulley, but it also tends to reduce accidents, as the belt does not revolve except when driving a power working machine. Where machines are operated only a part of the time, it also saves a considerable amount of power. It is impossible for the belt to shift from the idler to the driving pulley of its own accord. It is therefore an excellent safeguard against the unexpected starting of a dangerous machine.

On the left of Fig. 36, the belt is shown remaining stationary on the idler, with the main shaft revolving. On the right the idler is shown when relieved of the belt, the belt revolving on the driving pulley with the shafting.

Every power working machine should be equipped with an approved starting and stopping device in the form of a switch, friction clutch, tight and loose pulley, or belt idler and shifter. It has been conclusively proven that

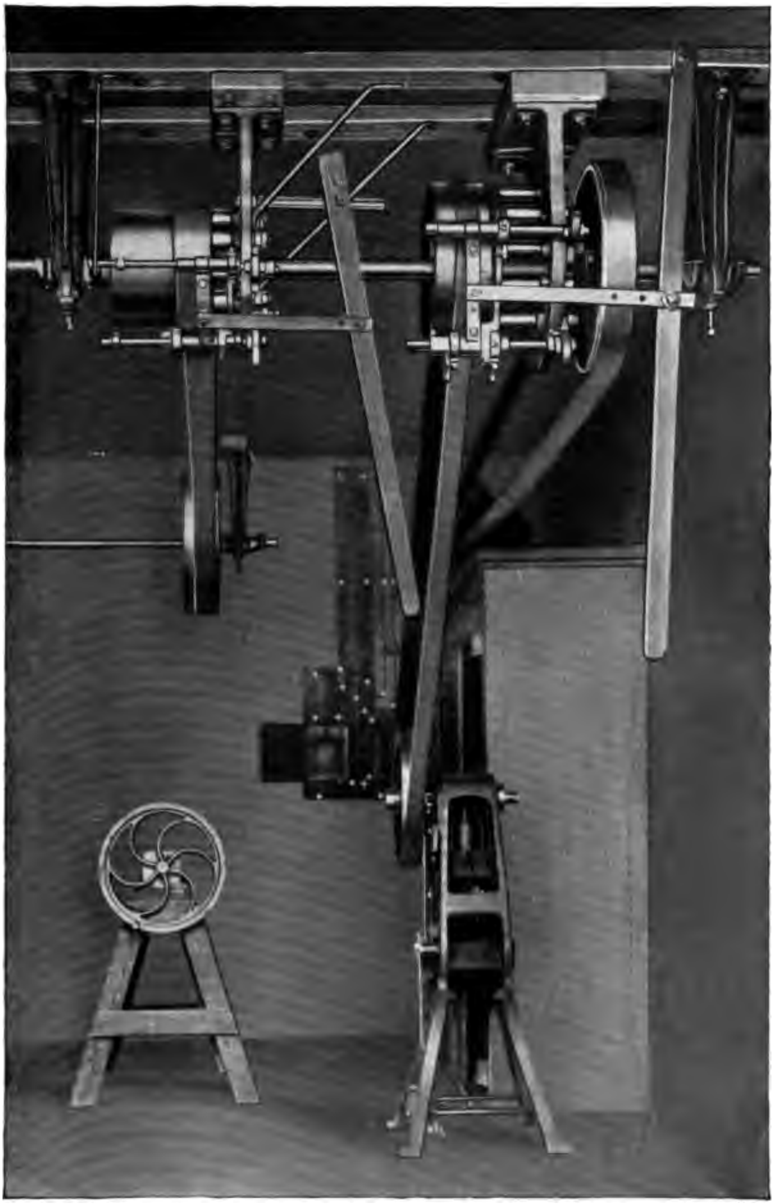


FIG. 36
Safety belt idler and shifter, showing punch press in operation with balance of machinery idle.

Courtesy F. A. Carlton, Syracuse, N. Y.

belts of any size are capable of being readily shifted if equipped with an approved belt shifter. Belts should not be shifted by hand or foot.

Handles of belt shifters should hang in a vertical position when on the loose pulley. This tends to reduce the possibility of the belt accidentally shifting to the tight pulley by a gravity leverage action on a handle which is not in the vertical position. In addition, the handle should be designed to lock on and off position by springing into grooved sockets in a wooden or metal horizontal bar, or by some other mechanical means. Many accidents result from the creeping of a belt from a loose pulley back upon a tight pulley, thus unexpectedly starting a machine.

CHAPTER XII

MACHINE TOOLS

For this chapter, several widely used machine tools have been selected for which safeguards will be described and illustrated. The principles of safeguarding herein set forth should be similarly applied to other machines.

Lathes. — All power driven gears should be completely encased with metal hoods or covers. (Fig. 37.) These guards should be made in one casting, and should be easily removable for changing and oiling the gears.

Safety cone belt shifters should be installed to eliminate the necessity of shifting the belt by hand. These cone belt shifters should also be applied to shapers, milling machines, drill presses, slotters, bolt cutters, boring mills, pipe machines, and other machines which are driven by means of cone step pulleys. These shifters not only provide a safe means of shifting a belt on a cone pulley, but they save a considerable amount of time which would otherwise be consumed in wrestling with a belt which must be shifted by hand. Arms and wrists are often broken, and hands and fingers slashed, in attempting to shift cone pulley belts by hand. The use of a belt shifter also allows a guard of angle iron and wire mesh to be placed about the belt and pulley, a slot being left in the wire mesh for the shifter handle.

The shifting device consists of two relatively fixed sections of rack, one mounted on the head stock, the other on the countershaft. A belt shifting bracket is mounted on each of these racks and operated by means of a pinion with two teeth, which engages the rack and moves the two brackets in the same direction, one in advance of the

other. The rack teeth are spaced one-half the width of the cone step, so that one complete revolution of the

FIG. 37
Safety cone belt shifter.
Courtesy R. K. Le Blond Machine Tool Co.

pinion moves the shifter bracket the full width of the cone step. A common crank, conveniently located, operates both pinions through a pair of miter gears and a telescopic

shaft, adjustable within certain limits for the height of the ceiling. One shifter always acts one half-revolution of the crank ahead of the other. The first half-revolution moves the belt from a larger to a smaller pulley on one of the shafts, and the next half-revolution moves the belt upon a larger pulley on the other shaft. When running, the crank always assumes the same position, convenient to grasp, the belt being locked against further movement except by turning the crank. A stop is pro-

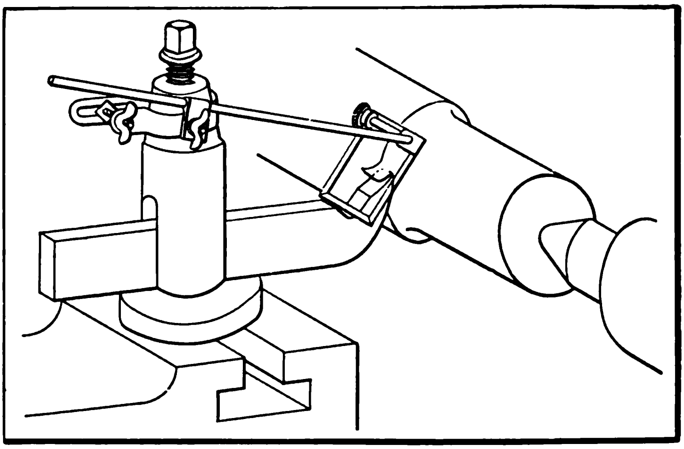


FIG. 38
Chip guard for lathe.
Courtesy Barcy-Nicholson Co., Detroit.

vided in both directions to prevent the belt being thrown entirely off the cone. With this device, the belt is longer lived, as the edges cannot curl up against the step of the cone. For this reason, wider belts may be used, giving greater power.

Fig. 38 shows a chip guard for a lathe in one of its many positions. These guards may also be used on hand-fed screw machines, on brass-work, and on other machines where metal chips are apt to fly from stock. The rod supports a removable glass window, and the guard is adjustable in each direction. Magnifying glass may be used

if desired. This guard enables the operator to watch the work closely without danger of flying chips lodging in his eyes. The clamp is also adjustable to fit different size toolposts. Similar guards may also be applied to shapers.

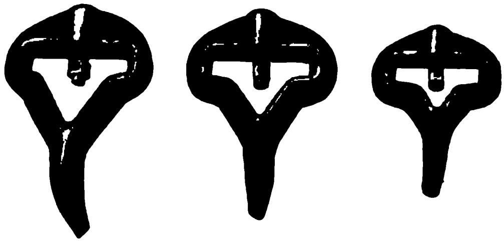


FIG. 39
Safety lathe dogs.
Courtesy Sargent Company, Chicago.

Safety lathe dogs should replace those of the old fashioned type. There are several safety types now on the market, one of which is shown in Fig. 39. The set screw should be of the headless variety, adjusted by means of a socket wrench; or, in case an ordinary set screw is used, it should be guarded by an outer rib forming a part of the dog itself. Accidents often happen where protruding unguarded set screws are used on lathe dogs, as the set screw may easily catch a loose or torn sleeve or jumper with disastrous results to the operator.

Chuck guards may also be used to advantage to cover projecting revolving parts which might otherwise catch the operator's clothing.

Operators should be instructed in the correct method of filing on a lathe, keeping the nearest arm well away from the revolving dog and chuck. Sleeves should be rolled up when working around these dangerous revolving parts of machines.

Planers. — A horizontal sheet metal cover should be placed upon the ribs of the bed of all planers. (Fig. 40.) This should cover the spaces between the ribs of the bed, thereby preventing anyone's hand or arm being caught between the ribs of the frame and the reciprocating carriage. If not so guarded, workmen frequently keep tools in the spaces between the ribs of the bed, or they may be

accidentally dropped there. In reaching for these tools, workmen occasionally lose a hand or an arm by the shearing action between the reciprocating carriage and a rib of the bed. Workmen might also slip in passing by the end of a planer bed, and in thrusting out a hand to avoid a fall, it might be caught and crushed in the manner de-

FIG. 40
Properly safeguarded planer.
Courtesy Crosby Company, Buffalo.

scribed. This metal cover eliminates any possibility of a workman being injured in this way.

Where a planer is operating with a long stroke, and the carriage at its farthest point approaches close to a fixed obstruction, such as a wall, the passageway between the obstruction and the bed of the planer should be guarded, preventing anyone being crushed at this point.

The belts and pulleys, and the gears of planers should be completely encased. Counterweights of planers, boring mills, drill presses, etc., should also be encased to the floor line, so that no one will be injured in case the supporting chain or rope should break.

Shapers. — Belts and pulleys on shapers should be completely encased to a height of 6 feet. A safety cone

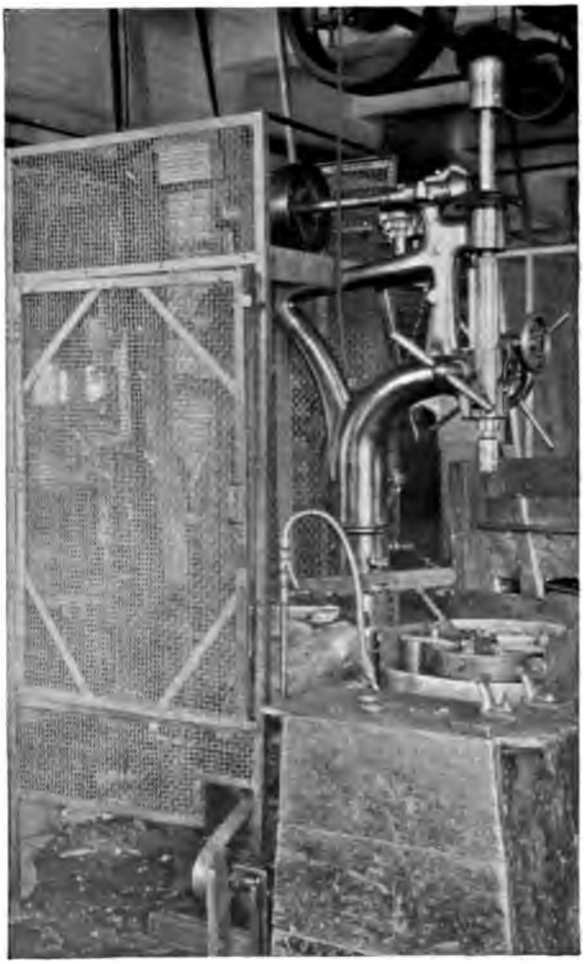


FIG. 41
Properly safeguarded drill press.
Courtesy Crosby Company, Buffalo.

belt shifter should be used for shifting the belt on the cone pulleys. A chip guard, similar to that described for lathes may also be advantageously applied to shapers.

Drill Presses. — All power driven gears, including the bevel gears, should be completely encased. Spindles should be encased with sheet metal tubes. A safety cone belt shifter should be provided. Belts and pulleys should be guarded to a height of 6 feet. (Fig. 41.) Set screws in the chucks of drill presses should be of the headless type and should not protrude beyond the surface of the chuck.

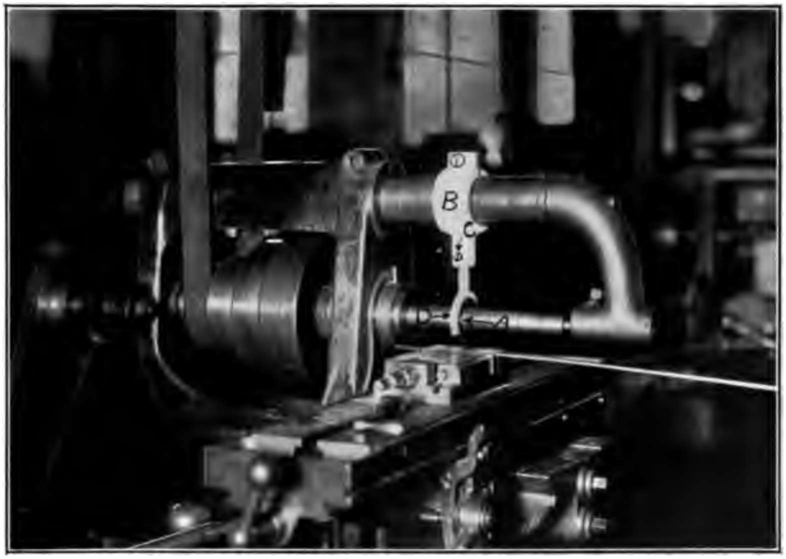


FIG. 42
Adjustable guard for milling machine cutter. Hood D is adjusted vertically by screw C.
Courtesy Eastman Kodak Company.

Milling Machines. — All power driven gears should be completely encased. Suitable guards should be provided for the cutters. (Fig. 42.) Safety cone belt shifters should be used. Belts and pulleys should be guarded to a height of 6 feet.

Punching and Stamping Presses. — Guards should be installed on all punching and stamping presses at the point of operation wherever their use is practicable in con-

nection with the operation to be performed. A great deal of attention has been devoted to safeguarding these machines, and many practical guards have been devised which are suited to various kinds of punching and stamp-

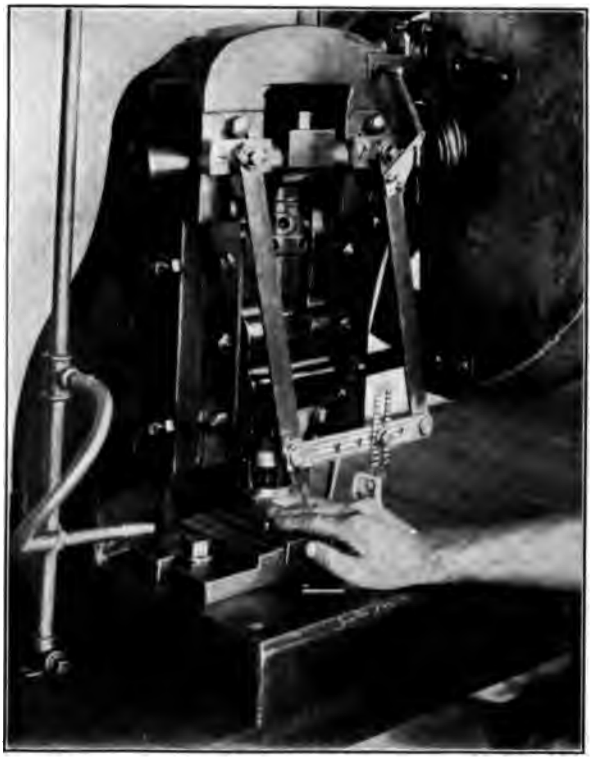


Fig. 43
Automatic punch press guard.
Courtesy Yale & Towne Mfg. Co.

ing operations, a few of which will be described and illustrated.

Fig. 43 illustrates one type of guard. The operator is shown as just having placed the material to be stamped in the nest, being about to press the treadle which will release the clutch. If the resistance of the hand against

the felt pad is greater than the pressure of the foot upon the treadle, the clutch cannot be released. Just as soon as the pressure upon the treadle becomes greater, however,

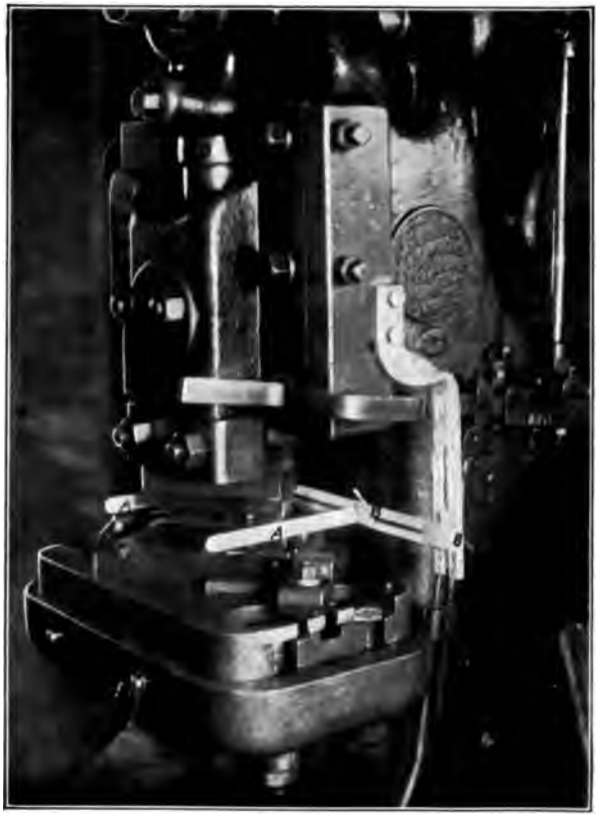


FIG. 44
Punch press with obstruction guards for blanking operation.
Courtesy Eastman Kodak Company.

the operator's hand will be pushed out from under the dies, releasing the clutch. This motion can be made to either the right or left by adjusting the guard accordingly. Raw material may be placed on either side of the operator. Instead of having a waste motion to overcome, he is aided in the direction of the next productive motion.

Fig. 44 shows a press guard for blanking operations, consisting of guards or stops "A" which are adjustable both horizontally and vertically by clamps "B." The

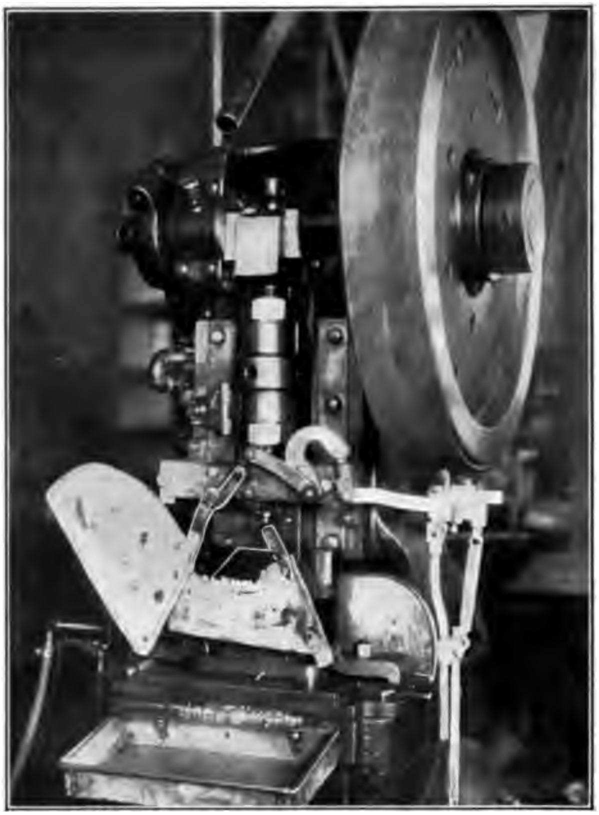


FIG. 45

Duplex punch press guard. Wing shields prevent the operator from accidentally placing his fingers underneath the dies. Positive and cautionary guards operate automatically.

Courtesy Eastman Kodak Company.

stops "A" prevent the operator from accidentally placing his fingers under the dies.

Fig. 45 illustrates another type of press guard. This consists of two wings as shown, which reciprocate back

and forth. Before the clutch can be released, the outer wing swings downward in front of the dies, sweeping aside the hand of the operator. As the die moves upward again, the rear wing sweeps downward, the outer wing returning to position. This prevents the operator's hand from getting under the dies. Both wings return to position before the next operation. In case the machine should repeat unexpectedly, there would be one wing in front of the dies, so that the operator cannot accidentally injure his hands.

Operators should be instructed in the proper method of placing material under the dies. The fingers should not be placed on top of a piece directly underneath the die. The correct way is to hold the piece at the sides, if possible, keeping the fingers out from under the die. In blanking operations, a mechanical roller feed should be used where possible, hand feeding being abolished. The material may be removed by mechanical means or by gravity. Slide or disc feeds may be used for small work.

Balance wheels, pulleys and belts should be completely guarded to a height of at least 6 feet. Gears should be completely encased. Where balance wheels cannot be enclosed, a disc of fiber or metal should be used to cover the spokes of the wheel.

All punching and stamping presses, shears, cutting machines, knife presses, and similar machines should be equipped with a safety device which will prevent them from repeating unexpectedly. There are several types of tripping mechanisms which require positive action on the part of the operator before the machine can repeat an operation.

Shears. — Fig. 46 shows a substantial, rigid, tinseled guard for a metal power shear. The bar rests in sockets on each side of the frame. The concave portions of the guard make it possible to place the hands very near the blade, but at the same time prevent the fingers from being cut.

Another safety device, which is commonly used on shears and cutting presses, consists of a handle on each side of the operator, connected to the tripping mechanism.

FIG. 46
Metal shear with steel tinseled guard at operating point.
Courtesy Eastman Kodak Company.

In order to trip the machine, the operator must pull both handles at the same time. This requires the use of both hands at the same instant, making it impossible for them to be near the blade.

CHAPTER XIII

GRINDING MACHINERY

THE principal causes of rupture of emery wheels are due to overspeeding, improper mounting, loose bearings, unrelieved and too small flanges, side blows from heavy castings, unbalanced and defective wheels, and to excessive vibration. Provision should be made for preventing the use of unsafe speeds or wheels with too large diameter. The supervision of emery wheels should be entrusted to a competent mechanic. Each wheel should be carefully examined and tested before being mounted. Each wheel should be provided with a substantial hood, capable of retaining parts in case of breakage. This hood should be connected to an efficient dust-arresting system. In no case, should operators be allowed to grind without wearing protection goggles.

Dust-Removing Systems. — Grinding rooms should be well ventilated and lighted. An efficient dust-arresting system should be installed. This will lessen the wear on machinery, as well as give proper protection to the workmen. If emery dust is breathed into the lungs, or gets into the eyes, it quickly causes inflammation. Serious results then follow. For this reason, the dust should be effectively removed by some approved system.

Mounting. — The stands of emery wheels should be sufficiently heavy and securely fastened to substantial foundations to prevent vibration. Spindles should be large enough to prevent springing from heavy pressure work. The boxes should be long enough to prevent heating and excessive wear. They should be well oiled, so that the arbor will not become heated and expanded, causing rup-

ture of the wheel. Wheels should not be loose on spindles, nor should they be forced on. They should fit snugly without binding. Wheels should run true and steady. If vibration is noticed, the wheels and journals may need truing up, or the journals may need re-babbitting. Wheels should be carefully unpacked and safely stored. They should be kept absolutely free from dampness. They should always be tested before mounting by tapping them lightly with a small hammer to detect cracks. If a wheel is cracked, it will not ring true when tapped with a hammer. The inner flange should be keyed or shrunk on the spindle. It should never be loose. Flanges should be at least ½ the diameter of the wheel. Wheels should never be held by a nut alone on the outer side. A proper size flange should be used. A nut is apt to crawl, causing an accident. Flanges should be relieved, with a true circumferential bearing on the wheel at the outer edge of the flanges. Unrelieved flanges do not properly distribute the pressure and are therefore unsafe. Fig. 47 shows the correct and incorrect methods of mounting an emery wheel.

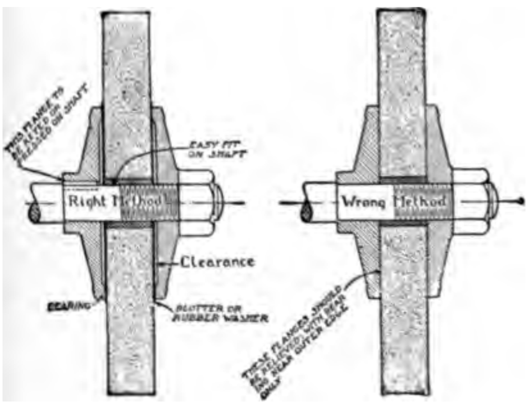


Fig. 47
Correct and incorrect methods of mounting emery wheels.

Courtesy Norton Company.

Compressible washers of pulp or rubber, slightly larger than the flanges, should be placed between the wheel and the flanges. These washers evenly distribute the pressure when the flanges are tightened.

The hole in the wheel should be bushed .005″ large

over standard size spindles. This permits the wheel to slide on the spindle without cramping, thus insuring a good fit, not only on the spindle, but against the inside flange as well.

Flanges should only be tightened enough to firmly hold the wheel, avoiding any unnecessary strain.

The following sizes of spindles are recommended, except where the grinding wheels are extra thick, in which case they should be larger.

Wheel	Diameter of Spindle
6″ in diameter and less	$\frac{1}{2}$″
8″ " " " "	$\frac{5}{8}$″
10″ " " " "	$\frac{3}{4}$″
12″ " " " "	1″
14″ " " " "	$1\frac{1}{4}$″
16″ " " " "	$1\frac{1}{2}$″
18″ to 20″ " " "	$1\frac{3}{4}$″
20″ to 24″ " " "	2″
24″ and larger	$2\frac{1}{2}$″ to 3″

Beveled, shoulder and ring flanges have more or less merit, but the wheel should also be surrounded by a substantial protection hood, as flanges do not afford protection from that part of the wheel outside of the flange in case of breaking. With the beveled type, a good fit of the beveled wheel and flanges is essential. These flanges should be relieved in all cases. Beveled wheels are impracticable when grinding into a shoulder or into a slot. Shoulder and ring flanges are designed to allow the use of wheels with straight sides. The maximum amount of wheel that should project beyond any type of protection flange is 2″. This necessitates a frequent change to flanges of smaller diameter.

Flanges on both sides of a wheel should always be of the same diameter. The set of the largest diameter should be used on the full size wheel.

Tool rests should be kept in close adjustment to the wheel, so that the piece cannot be caught between the wheel and the tool rest. If this should happen, the wedg-

ing action would probably cause the wheel to break with disastrous results. A chain hoist should be used to support a heavy casting when grinding. This will enable the operator to safely hold the casting against the wheel, avoiding dangerous side blows which might rupture the wheel. Special tables or rests may also be used for this purpose.

Speed. — As a wheel wears, the speed should be increased in order to maintain the same surface rate and to

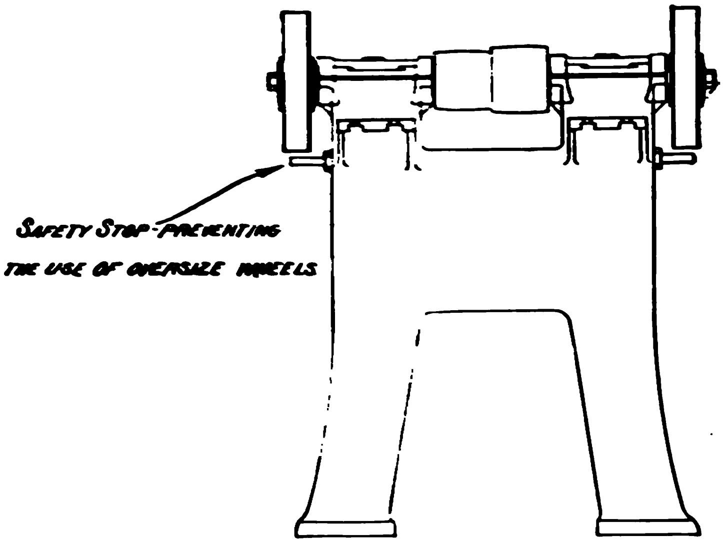


FIG. 48
Safety stops to prevent use of oversize wheels.
Courtesy Norton Company.

preserve uniform conditions in grinding. Usually, when a wheel is nearly worn out, the spindle is running at its highest speed. If a thoughtless operator takes off the stub of an old wheel and puts on a new wheel without readjusting the belts, an accident from overspeeding is likely to occur.

Fig. 48 illustrates the method of using safety stops to prevent the use of oversize wheels. These are useful in shops where, instead of shifting the belt, two or three

sizes of machines are used which run at different speeds. When a wheel is worn down to a certain diameter, it should be changed to a spindle on another machine which runs at a higher speed. This device prevents the use of wheels of over a fixed diameter.

In case emery wheels are driven by variable speed motors, in lieu of constant speed motors, a speed limit device should be used. This should be automatically dependent upon the diameter of the wheel.

Operators should not be allowed to grind until the man in charge makes sure that the wheels are running at a safe speed. The belt should be so locked that the speed cannot be changed by the operator. Every morning, the foreman of the grinding department, or his assistant, should carefully examine each grinding machine to see that the bearings are tight and well oiled, and that the wheels are in good condition. He should test and examine every wheel before it is placed on an arbor. Competent workmen should be detailed to mount and true grinding wheels, adjust rests, and regulate the speed.

The following table, compiled by The Norton Company, gives a tabulation of revolutions per minute in relation to surface speeds:

TABLE OF GRINDING WHEEL SPEEDS

Diameter Wheel	Millimeters	Rev. per min. for surface speed of 4,000 feet or 1,200 meters	Rev. per min. for surface speed of 5,000 feet or 1,500 meters	Rev. per min. for surface speed of 6,000 ft. or 1,800 meters
1 inch	about 25	15,279	19,099	22,918
2 "	" 50	7,639	9,549	11,459
3 "	" 75	5,093	6,366	7,639
4 "	" 100	3,820	4,775	5,730
5 "	" 125	3,056	3,820	4,584
6 "	" 150	2,546	3,183	3,820
7 "	" 175	2,183	2,728	3,274
8 "	" 200	1,910	2,387	2,865
10 "	" 250	1,528	1,910	2,292
12 "	" 305	1,273	1,592	1,910
14 "	" 355	1,091	1,364	1,637
16 "	" 405	955	1,194	1,432
18 "	" 455	849	1,061	1,273
20 "	" 505	764	955	1,146
22 "	" 555	694	868	1,042
24 "	" 610	637	796	955
26 "	" 660	586	783	879
28 "	" 710	546	683	819
30 "	" 760	509	637	764
32 "	" 810	477	596	716
34 "	" 860	449	551	674
36 "	" 910	424	531	637
38 "	" 965	402	503	603
40 "	" 1,005	382	478	573
42 "	" 1,065	364	455	546
44 "	" 1,115	347	434	521
46 "	" 1,165	332	415	498
48 "	" 1,220	318	397	477
50 "	" 1,270	306	383	459
52 "	" 1,320	294	369	441
54 "	" 1,370	283	354	425
56 "	" 1,420	273	341	410
58 "	" 1,470	264	330	396
60 "	" 1,520	255	319	383

The r. p. m. at which wheels are run is dependent on conditions and style of machine and the work to be ground.

Wheels are run in actual practice from 4,000 to 6,000 feet per minute; in some instances as high as 7,500.

Grinding wheels should be stored in a dry place. A wheel which is used for wet grinding should not be left

over night partly immersed in water, as the wheel would then become decidedly unbalanced, and hence dangerous.

A notice should be hung above grinding wheels giving the machine number, spindle revolutions per minute, and the maximum safe diameter of wheel. Wheels should be kept properly dressed and in good condition. A guarded dressing tool should be used for this work. Tachometers should be kept in a handy place for use in determining the number of revolutions per minute in testing for safe speeds.

Wheels which are made with a bond of a high tensile strength, and those which are made of a fine grain, have a higher factor of safety than soft and coarse wheels of equal size.

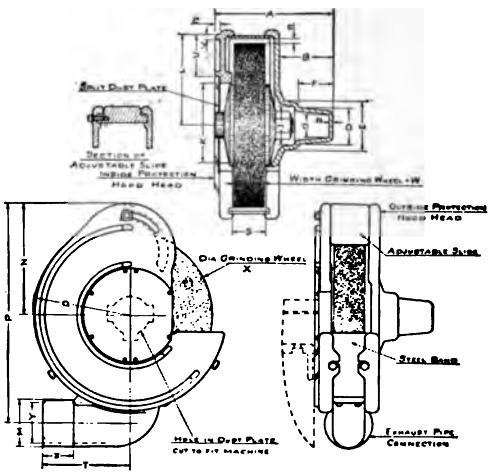


Fig. 49
Most approved form of adjustable, steel, retaining and exhaust hood for emery wheels.
Courtesy Norton Company.

Hoods and Guards. — All emery wheels should be provided with a substantial steel hood, or a steel strap, to prevent broken pieces from flying in case the wheel breaks. Cast iron should not be used as it is unreliable.

Fig. 50 shows grinding wheels thoroughly equipped with a substantial retaining steel hood which also serves as a dust arrester, being connected to an efficient exhaust system. The hoods are provided with adjustable glass guards to prevent particles and dust from flying into the eyes of the operator. Note the guard for the belt and spindle pulley.

All belts and pulleys of emery wheels should be guarded,

with either sheet metal or wire mesh, attached to an angle iron frame.

All operators should be required to wear suitable goggles.

Fig. 50

Adequate protection for emery wheels. Steel exhaust hoods, glass eye protectors, and sheet metal belt guard.

Courtesy Norton Company.

Respirators should be provided where dust is of a poisonous nature.

All buffing and polishing wheels should be equipped with hoods and an efficient exhaust system to remove all dust.

The arbor ends of all grinding, buffing and polishing

wheels should be so covered that loose or torn clothing cannot become caught and wound on the exposed end of the arbor.

Observations. — As a result of extensive tests and

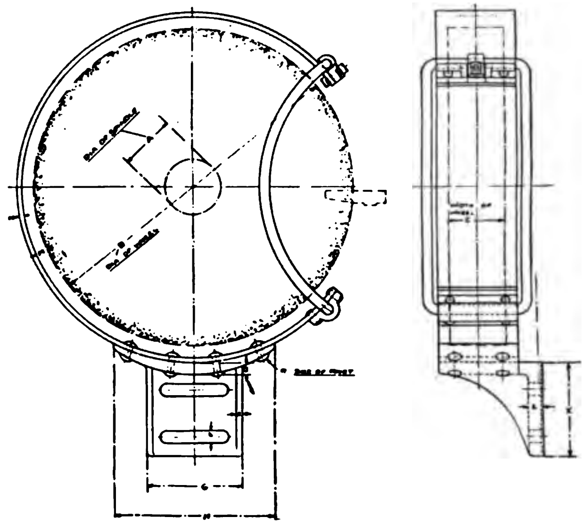


FIG. 51
Strong steel band for emery wheel. Used when hoods would interfere with side grinding. Band is amply strong to retain parts in case of breakage.

Courtesy Norton Company.

experiments on emery wheels by The Norton Company, the following facts have been established:

1. The tests conducted and the mathematical deductions arrived at show that protection hoods provide greater safety than do safety flanges.
2. The protection offered by any given taper decreases with decreased diameter of the wheel. To provide equal safety on all sizes of wheels would require, therefore, a graduated difference in taper.
3. A hood with an adjustable tongue furnishes equal protection for a wide range in the diameter of the wheel.
4. Second to safety, the cost of operating a given grinding machine is of vital interest. In this respect, adjustable hoods have the better of the argument, for, as the wheel wears, protection flanges must be frequently changed. Such change involves the removal and remounting of both flanges and the wheel, whereas, in the case of an adjustable hood, the change would merely involve the set screw adjustment.

5. To provide adequate protection for wheels 3" thick and over, the thickness (hence the weight) of flanges would have to be increased beyond that of any now on the market. This would mean additional momentum to the revolving spindle, which in turn would require greater rigidity and strength than is to be found in the majority of present day grinding machines.

6. Since the face of a tapered wheel becomes wider as the diameter increases, serious inconvenience is caused in all grinding where the wheel must work in a slot.

7. Tapered wheels do not permit the grinding of right angle shoulders as do straight wheels.

8. Laws in most every country require the removal of dust from grinding. This requires the use of a hood. If a hood must be used, it might as well be strong enough to offer protection in case the wheel should break.

9. A proper hood offers complete protection. Protection flanges cannot offer this complete protection, but in instances where a hood would interfere with the proper use of the wheel, flanges offer the next best method of protection.

CHAPTER XIV

WOODWORKING MACHINERY

WOODWORKING machinery is exceptionally hazardous. It should, therefore, receive special attention. Every effort should be made to provide adequate and effective guards for this class of machinery. Even when properly safeguarded, woodworking machines are always a source of danger for the reason that they cannot be made entirely "fool-proof." Automatic self-feeding devices have been successfully applied to some of the machines with good results. Where these devices are used, most of the danger is eliminated. It is, however, impossible to use self-feeding devices for many operations. Skilled workers, who have gained long experience in the operation of woodworking machinery, are by no means exempt from danger. Many, who have worked on these machines for a lifetime, become finally injured. A thoughtless and careless movement, or the lack of close attention to the work for a fraction of a second, may result in the loss of several fingers or a hand.

This class of machinery is operated at high speeds. It is thus important to guard all belts, pulleys, sprockets, and gears in addition to providing suitable guards at the point of operation. Wooden flooring becomes very slippery in a carpenter shop, therefore, it is desirable to provide non-slip mats for the operators to stand upon. For this purpose, corrugated rubber matting or other material may be used. The mats should be cemented to the floor to prevent the corners from curling. As soon as mats become worn or cut, they should be replaced.

Circular Saws. — Fig. 52 shows an improved type of automatic saw guard. The hood is made of aluminum to

secure the lightest weight consistent with strength. The front of the hood is open to permit a full view of the blade when matching or cutting off to a line. The hood is free to travel either up or down on hardened rollers in the slot of the spreader. The spreader is made of saw steel to give the necessary rigidity. There are no obstructions overhead or at the side of the table. A narrow strip can be cut while the guard is giving full protection by

FIG. 52
Automatic circular saw guard.
Courtesy Surty Guard Company, Chicago.

placing a piece of the same thickness between the material and the guide, thus keeping the guide farther away from the saw. The supporting spreader prevents material from binding the saw. It also prevents ends from getting on the back of the saw when cutting off. A dog, attached to a side of the hood near the rear, prevents a "kick-back" of material in case it becomes caught by the saw. The guard is automatic and does not interfere with the work of the operator, but, at the same time, affords ample protection.

Fig. 53 shows another type of guard which is supported from overhead, securely stayed by means of rods and turnbuckles. The hood is made of aluminum to make the guard as light as possible. The stock, which is attached to the hood, slides up and down on rollers within the sleeve. This guard is adjustable both horizontally and vertically, and is automatic. It may be easily shoved aside for special work. The hood is also provided with a dog to prevent "kick-backs." As a piece of wooden stock is shoved against the buffers the hood is automatically shoved upward for the necessary distance to allow the stock to be sawed, according to the thickness of the piece, the method of operation being very similar to that of the guard previously described.

FIG. 53
Suspended automatic saw guard.
Courtesy Lockhart-Hodge Co., Inc., Buffalo.

The gauge or guide of a saw table should be low enough to allow the operator the safe use of his hand between the saw and the guide. If the guide is too high for narrow work, a push stick should be used to shove the piece through, thus keeping the hand from the danger zone. (Fig. 54.) The saw table should be provided with a device which will permit changing from a low gauge to a high gauge, or vice versa, to suit the requirements of the work. The gauge should never be adjusted while the saw is running. The height of the saw above the table top should be adapted to the thickness of the material to be sawed. The teeth of the blade should protrude above the top of the table no farther than is necessary. If there

is any evidence of cramping when sawing a piece, the operator should immediately place a strong grip on the piece to withdraw it. At the same time the saw should be quickly stopped. For this purpose a belt shifter should be so arranged that it can be operated with ease by a movement of the foot or leg of the sawyer, thus allowing him the use of both hands in this case. The relative direction of pushing a lever, and the position of the lever, should be

FIG. 54
Push stick for narrow work on circular saw and automatic guard for saw.

the same for all saws in the factory, so that in an emergency, an operator will not be at a loss to know exactly what move to make to stop a saw. An operator should have a clear view of the blade when sawing material. Self-feeding devices should be used where possible, as they greatly diminish the danger of injury to an operator.

Swing Cut-off Saws. — The belt and pulley should be completely guarded to a height of 6 feet from the floor level. (Fig. 55.) A metal guard should completely cover

the upper half of the blade. The handle should be placed away from the metal guard for the saw, so that it will be unnecessary for the operator to place his hand near the

FIG. 55
Properly guarded swing cut-off saw. Metal hood for saw, limit chain to prevent saw from swinging outward beyond edge of bench, guarded belt, and safety chain for overhead counterweight.

blade. If the machine is not mounted in front of a wall of the building, the rear of the machine should be guarded to prevent anyone being cut should the saw be swung too far backward. A limit chain should be attached to the

swing stock and fastened to the wall in the rear, thus limiting the distance through which the saw may be swung outward from the wall. A safety chain from the ceiling should be attached to the counterweight to prevent it from falling in case it should work loose from the balance arm.

Band Saws. — Fig. 56 illustrates the correct method to guard a band saw. The wheels are enclosed with a guard of wire mesh and angle iron. The guard for each wheel is built in the form of a door, which is mounted on hinges, the door being locked closed by means of a thumb screw. An angle iron guard is attached to the guide, completely covering the working side of the blade between the guide and the upper door. A guard is also placed above the guide, at the side, to prevent the saw band from flying off in case it should break. Heavy self-feed band saws should be guarded similarly to hand-feed machines.

FIG. 56
Properly guarded band saw.
Courtesy J. A. Fay & Egan Co.

Jointers. — Fig. 57 is a view of a jointer guard. This guard is automatically adjustable in two directions. When rabbeting, the guard can be turned over to the end of the table, leaving the table and groove clear. When edging, the guard swings on the brass tubes R which are pivoted to the shield T and casting S. The spring U keeps the guard or shield against the board or fence. When surfacing, the shield is automatically raised as a board is pushed against the buffer Y. The casting S is hinged on the steel

rod A. The spring B carries most of the weight of the shield T which is made of aluminum to secure lightness consistent with strength. When edging, the shield is automatically pushed horizontally aside to the width of the piece. When surfacing, the shield is pushed vertically upward to the thickness of the piece. The knives are thus completely covered at all times.

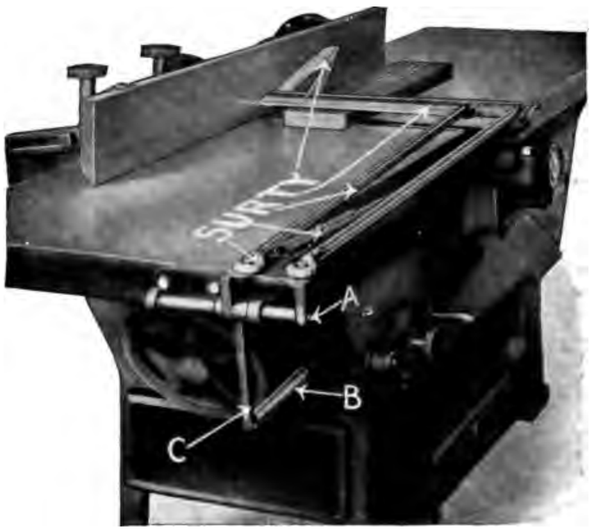


Fig. 57
Automatic guard for jointer.
Courtesy Surty Guard Company, Chicago.

Fig. 59 shows another type of jointer guard. It consists of thin wooden slats which are linked together and attached to a steel arm and buffer. The guard is flexible and folds over the edge of the bed. It moves back and forth over a roller which is attached to the side of the table, thus minimizing the friction. The buffer is normally held in contact with the guide by means of a spring at the pivot point, except when stock is being pushed over the knives. The guard is then automatically pushed away from the guide for the width of the piece. The tension

in the spring is adjustable. A sliding clip, which is mounted on the arm, may be used in contact with the edge of the table to hold the guard in a certain position when pieces of the same thickness are to be run on the machine. For

FIG. 58
Automatic jointer guard in operation showing complete covering for cutting knives.

rabbeting, a supporting pin may be easily pulled out and the guard lowered from the bed of the table.

Cylindrical safety cutter heads should be used on all jointers. (Fig. 61.) The old square head type is especially dangerous. If the latter type is used and an accident occurs, a workman will be very apt to lose the whole of one or more fingers, whereas, if the former type is used, the chances are that the workman would lose only the

tips of his fingers. In case of the cylindrical safety cutter head the large open space in the square cutter head is filled. Thus, in the round type, there is not space enough to instantly draw in the whole of a workman's fingers. The use of the cylindrical safety cutter head has saved a great many fingers which would have otherwise been lost. The space in front of the knife is filled by the

FIG. 60
Automatic guard for jointer.
Courtesy J. A. Fay & Egan Co.

FIG. 59
Automatic guard for jointer.
Courtesy Champion Machinery Co., Joliet, Ill.

FIG. 61
Modern safety cutting head of jointer. No large space exists between cutting head and throat. These safety cylindrical cutting heads are far superior in point of safety to the old style square cutting heads.
Courtesy J. A. Fay & Egan Co.

throat piece, so there is no chance for chips to drive under the knife. The throat space under each knife is made

quite small in order to make the head as safe as possible. The throat space is large enough, however, to carry off chips for heavy cuts and fast feeds. A jointer guard should always be used in connection with the safety head, as well as with the square head, as the safety feature of the cylindrical head does not eliminate the danger of an operator being cut; it simply lessens the degree of an injury if the operator should meet with an accident. The guide of a jointer should never be adjusted when the machine is running.

Fig. 62

Old style, unsafe, square cutting head of jointer. Note large open space between cutting head and throat in which an operator's fingers might be caught and drawn in.

Courtesy J. A. Fay & Egan Co.

For "short" work on a jointer, a push block should be used to keep the hand from the danger zone. (Fig. 63.) This push block should resemble a carpenter's hand planer,

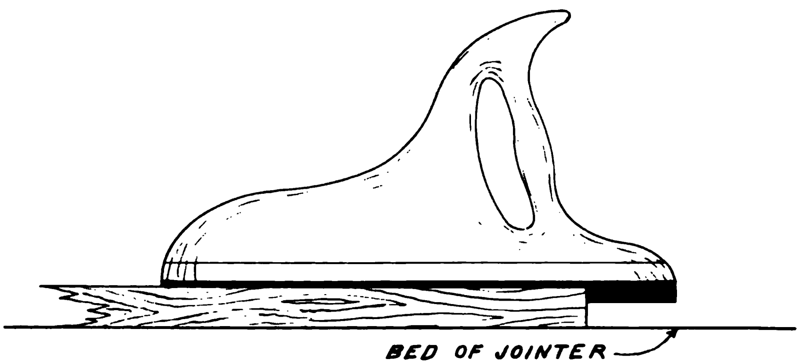


Fig. 63

Push block for short work on jointer.

having a handle and also a notch in the rear to fit on the end of a piece. Thus a short piece may be easily and safely pushed over the knives, the handle permitting a firm down-

ward and forward pressure. Self-feed jointers should be used where possible. They not only save time and labor, but also a great many accidents.

Shapers. — Fig. 64 shows a set of shaper guards, one in position, and one thrown upward out of the way for special work. These guards not only afford a protection to the operator from the fast revolving knives, but they also serve to steady the work. There are many different types of shaper guards which may be used for certain requirements of the work.

FIG. 64
Guards for cutting heads of shaper.
Courtesy Lockhart-Hodge Co., Inc., Buffalo.

FIG. 65
Boring auger guard.
Courtesy J. A. Fay & Egan Co.

Cylindrical safety shaper heads, similar to those in use on jointers, should be employed on shapers whenever possible. When used with straight knives, they have all the advantages of the safety jointer heads.

Miscellaneous. — Wherever possible, woodworking machines should be equipped with dust hoods connected to an efficient exhaust system. In many cases the hood acts as a safeguard, as on stickers, tenon machines, etc., covering the knives to some extent. Many home-made guards for different purposes can be devised which will greatly lessen the hazard on certain machines.

CHAPTER XV

COMMON MACHINES

Several common types of machines have been selected for which safeguards will be described and illustrated. No attempt will be made in this book to cover the field of industrial machinery, but the principles of safeguarding which are set forth in this book will serve to stimulate further ideas for safeguarding other types of machines.

Cylinder Printing Presses. — The opening in the frame at the end of cylinder printing presses should be guarded with a removable screen which may be hung on the frame. (Fig. 66.) This will prevent anyone being injured by the reciprocating bed or carriage. The cam near the floor at the side of the press should be guarded to prevent anyone being caught by the crank and the rod. Drive belts and pulleys and all gears should be completely encased. Projecting keys and set screws should be covered or countersunk. Platforms should be provided with a handrailing with a toeguard at the bottom. Cylinder presses are rather dangerous machines at best on account of having so many moving parts.

Job Printing Presses. — These machines should be equipped with an automatic guard at the point of operation, making it practically impossible for an operator to accidentally injure his fingers or hand by the crushing action of the jaws as the press closes. (Fig. 67.) The guard consists of a sliding gate attached to the sides of the moving jaw. When the press is open, the horizontal bar of the gate rests at the top of the jaw. As the press closes, the gate automatically slides upward, shoving the hand of the operator away from the danger zone. This guard is

also applicable to similar machines which are used for cutting, scoring, creasing, and embossing. It is an excellent device and is widely used. It affords the operator absolute protection and does not interfere with the work in any way. The balance wheels of jobbing presses should be guarded with wire mesh and angle iron. If more convenient, the balance wheel may be provided with a disc which covers the spokes of the wheel on the exposed side.

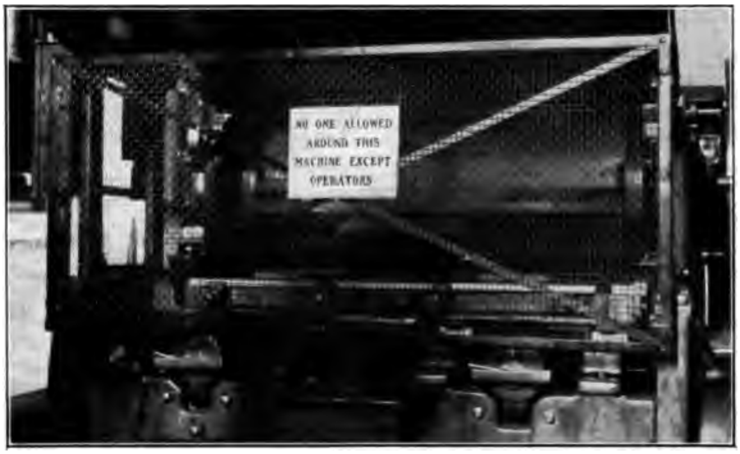


FIG. 66
Wire mesh guard hung on frame at open end of cylinder printing press to prevent workmen being injured between the reciprocating bed and framework.
Courtesy Bausch & Lomb Optical Company.

Type Casting Machines. — Exhaust hoods should be provided to remove all fumes. A piece of sheet metal should be placed over the vent to prevent molten metal from being blown into the face of the operator in case it becomes temporarily clogged. When working on these machines, operators should wear goggles. Large melting pots for type metal should also be equipped with exhaust hoods with sufficient suction to remove the poisonous fumes which are generated.

Cutting Presses. — Cutting presses should be equipped

with a non-repeating device to prevent the knife from falling a second time unless intentionally tripped by the operator. Operators frequently place their hands under

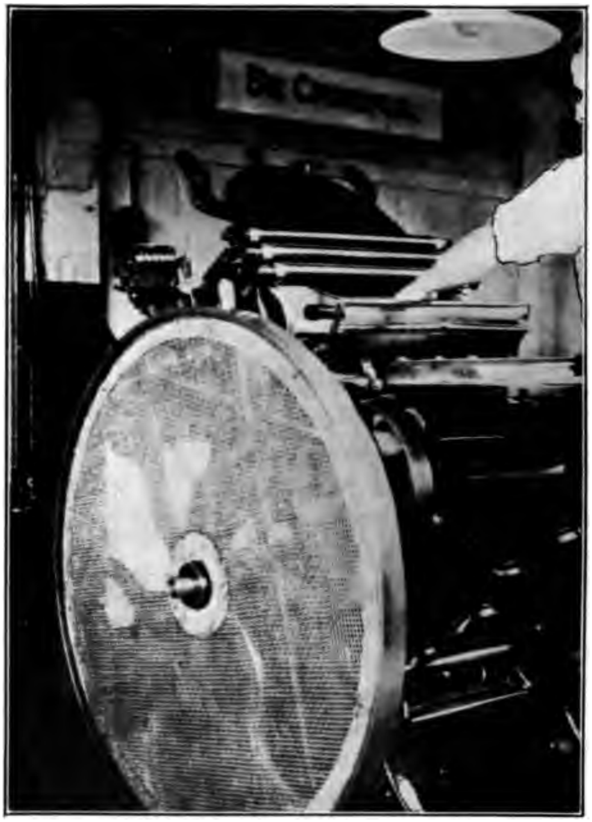


FIG. 67
Automatic hand guard for job printing press, and disc covering spokes of balance wheel.
Courtesy Taylor Instrument Companies.

the knife immediately after cutting in order to remove the waste material. Unless the cutting press is equipped with a locking device to prevent it from accidentally repeating, the operator is very apt to lose several fingers in this way. The material to be cut should always be securely clamped

to the bed before the press is tripped. A safety device, consisting of two hand levers, one on each side of the press, should be provided. This should be connected to the tripping mechanism. It should only be possible to

FIG. 68
Guards for hand-power paper cutter.
Courtesy Western Electric Company.

trip the press by pulling the two hand levers just described at the same time. This insures perfect safety as both hands of the operator must be on the handles and away from the danger zone as the knife descends.

Hand power cutting knives should be guarded with a wire mesh enclosure. (Fig. 68.) The counterweight should also be guarded. Stops should be placed at the outer end

of the counterweight arm to prevent the counterweight from falling off in case it should work loose. Similar counterweights of other machines should also be guarded in this way.

Corner Cutters. — Corner cutters should be guarded by an obstruction bar at the point of operation, the material

FIG. 69
Paper corner cutter guard.
Courtesy M. D. Knowlton Co., Rochester, N. Y.

to be cut being pushed under the bar. (Fig. 69.) The guard should be adjustable vertically. This guard will prevent the operator's fingers from being cut as the knife descends. The guard does not interfere with the work in any way and, at the same time, affords good protection.

Corner Staying Machines. — A new safety head for these machines is now on the market. (Fig. 70.) It is so

designed that if anything the thickness of $\frac{5}{32}$ of an inch remains between the jaw and the anvil, the machine

FIG. 70
Automatic safety head for corner staying machines.
Courtesy M. D. Knowlton Co., Rochester, N. Y.

cannot be tripped. A person's fingers must therefore be removed before the pressure jaw can close on the anvil. This insures absolute safety.

Roll Feed Machinery. — This class of machinery is

especially hazardous unless properly safeguarded. The principles of guarding roll feed machinery are illustrated

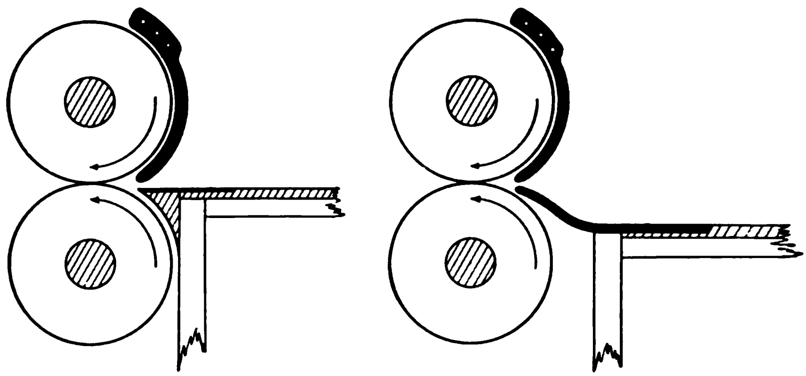


Fig. 71
Guards for roll feed machinery.

in Fig. 71. These devices prevent the rolls from engaging the operator's fingers and drawing them in. Roll feed machinery is encountered in sheet metal works, machine shops, rubber factories, textile mills, bleacheries, paper mills, rolling mills, candy factories, gum factories, bakeries, laundries, and other places. In nearly all cases, rolls may be so guarded by one of several methods as not to interfere in any way with the operation of the machine.

Fig. 72
Exposed gears at end of spinning frame.
Courtesy Mason Machine Works, Taunton, Mass.

Textile Machinery.—The low class of labor which is generally employed in textile mills, and the employment of minors, makes it imperative to adequately guard all

gears, sprockets, rolls, and belts and pulleys on pickers, cards, garnett machines, spinning frames, mule frames, drawing frames, looms, warpers, slashers, winders, etc.

Fig. 72 shows exposed gearing at the end of a spinning frame. Fig. 73 shows the most approved method of guarding these gears. The locking mechanism on the door should be so designed that the machines cannot be started until the door is closed and latched, and so that the door cannot be opened until the machine is stopped.

FIG. 73
Guarded gears at end of spinning frame.
Courtesy Mason Machine Works, Taunton, Mass.

Shuttle guards should be used for all looms.

Lap machines should be provided with a hood to cover the rolls, preventing the operator's hand being caught by carelessly tucking in the lap as the rolls are revolving. The guard should be designed to mechanically lock and unlock, so that it must be closed before the machine can be started, and not unlocked before the machine is stopped.

Fig. 74 illustrates the application of a beater lock to a finisher. This device is also applicable to breakers and intermediates. This device renders it impossible to start the machine when either the beater bonnet or glass door is open; also, making it impossible to open

either the beater bonnet or glass door when the machine is running.

The operation of the beater lock is as follows: The forked arm of the lock is mounted on a suitable stand fitted with a slide bearing which permits the arm to be moved in and out. Two of the arms are so made that when pushed in on slide they press against the glass door and the beater bonnet in such a way that these strips

FIG. 74
Beater lock applied to a finisher.
Courtesy Saco-Lowell Shops, Lowell, Mass.

cannot be raised. When set in this position, the perforated disc is applied to the beater shaft and so fastened that it clears the end of the third arm. This is the position of the lock when in operation.

When it is desired to open the beater bonnet, the slide is pulled outward. The end of the third arm, mentioned above, engages with slots in the disc on the beater arm, so that the beater cannot be turned. At the same time, the locking arms release the bonnet and glass door, so that they may be opened.

Fig. 75 shows one method of guarding sewing machine belts and shafting. These guards are made in sections and

can be easily removed for cleaning, as they are fastened in place by hooks. Needle guards should be placed on sewing machines, button machines, and buttonhole machines, otherwise, accidents will result from needles occasionally piercing the fingers of operators.

Hydro-Extractors. — Fig. 76 shows a cover guard for

FIG. 75
Guard of wire fabric for belts and shafting of stitching machines. Old style skirt board shown at left.
Courtesy Norwich Wire Basket Co., Norwich, N. Y.

an hydro-extractor. When closed, the guard effectively prevents an operator from attempting to place in or remove any material from the tub. At the same time, the contents are not obstructed from view. The guard cannot be raised until the driving belt is shifted to the loose pulley and the machine stopped. The machine cannot be started until the guard is in position.

FIG. 76
Hinged guard, with automatic power control, for hydro-extractor.
Courtesy Tolhurst Machine Works, Troy, N. Y.

CHAPTER XVI

IRON AND STEEL

Blast Furnaces. — All stairways, runways and platforms about blast furnaces and gas washing apparatus should be provided with hand rails and toeboards. The outrigging and bustle pipes should be equipped with railed walks, with iron stairways or stationary iron ladders leading to them. Properly railed platforms should be placed at all explosion doors. All platforms, runways and walks about blast furnaces should be covered with sheet steel, to protect workmen from slips of the furnace. Railed stairs and runways should be placed at the ends of the sides of cast houses, to afford a safe means of egress. The elevated floors of cast houses should also be equipped with hand rails and toeboards. All blast furnaces should be connected by railed walks, with solid bottoms and 12" guard plates.

A steel roof should cover all points where men work around blast furnaces. The sheeting on the sides of cast houses should extend downward far enough to prevent a storm from beating in, and to prevent hot stock being thrown in by slips from other furnaces. Hoisting machinery, cranes, and other machinery near a blast furnace, should be covered with a roof. This will protect the men from hot metal and other falling material.

All gas washers and gas mains should be provided with valves at each end, by means of which the gas can be entirely shut off. Explosion doors should be so built that nothing but gas and fine powdery ore can escape from the furnace. All tuyeres should be equipped with approved sights, affording ample protection to the eyes. Where

ladles are loaded under the floor, casting holes should be covered with a heavy iron grating, or suitably railed off. A shield should be placed at the tapping hole. This should be so constructed that the hole required for the drill be only large enough to permit its free movement. Cinder notches should be provided with shields which will protect workmen when botting them. Gates in iron and cinder runners should be operated from such a distance that workmen will not be in danger of being burned. Pressure gauges, snort valve levers, and whistle switches should be provided with shields.

Telephones should be installed at the tops of furnaces for the use of signalmen, or men engaged in repairing. There should also be telephone connection between the skip hoist operator's house and the blower's office. Signal whistles in the blowing engine-room should be operated from a switch in the cast house. A pilot lamp should be located at the switch, indicating when the circuit is closed. To prevent a mistake in distinguishing the sound of similar whistles, the number of the furnace from which the signal is blown should be shown by a light in the power house, visible to the engineer.

Mud guns should be equipped with a funnel-shaped casting over the receiving hole of mud cylinders; also, with a shield to prevent molten metal from burning the workmen.

No workmen should be allowed above the charging floor or bustle pipes, without permission from the foreman, on account of the danger from gas. Suitable helmets and oxygen-breathing apparatus for rescue work should be kept at a convenient place. These should be used when working in an atmosphere saturated with gas. Each blast furnace plant should maintain a trained crew of workmen for rescue work.

BLAST FURNACE RULES

1. Work around blast furnaces is very dangerous on account of possible explosions, escaping gas, blowing out of hot stock from the top of the furnace,

and the possible breaking out of the sides of the furnace. These dangers cannot always be guarded against by those in charge. Consequently, everyone near a blast furnace should be particularly watchful of his personal safety.

2. You are particularly warned that it is impossible for those in charge to know at all times when a furnace is likely to throw out hot stock. When it is known that a furnace is likely to slip, a warning will be given.

3. There is danger of your being overcome with gas, if you go above the floor around the bustle pipes, water troughs, roofs and stoves. Never go on top of a furnace unless there are two or three men with you. First, obtain permission from the foreman.

4. Never go on top of a furnace that is hanging or working badly. There is danger of an explosion.

5. Before working about explosion doors, and when necessary to open the gas seal, see that the gas valves are closed. Be sure that steam has been turned on the dust catcher. There is little danger of a gas explosion when the gas mains and dust catchers are under pressure.

6. Do not look through peep holes of a furnace unless it is one of your duties.

7. Before taking the blast off, for any purpose, as for changing a tuyere, notice should be given to the person in charge of filling the furnace, to stop filling until he receives word that the tuyere has been changed, or the blast put on the furnace. This will guard against gas being blown on the men through the tuyere openings.

8. Before pulling a tuyere, the opening should be thoroughly stopped with clay.

9. Pipe connections on tuyere and cooler should be made before blast is turned on a furnace.

10. When blowing out blast furnaces, water should be placed in try holes and on the big bell. The big bell should be kept partially open by hanging cables or rods through the opening between bell and hopper. When gas is no longer suitable for stoves or boilers, and when water seals have to be filled, steam should be immediately turned on all dust catchers, thus driving the gas out of the top of the furnace where the bleeders are open. All bleeders on dust catcher system should be kept closed.

11. When a blast furnace is blown out, wind being taken off and blow pipes dropped, it should be completely roped off. No one should be allowed access to the furnace for at least twenty-four hours. After the blast is taken off, the blow pipes should be taken down, one at a time, around the furnace.

12. When blowing in a blast furnace, no charging should be carried on after the furnace is lighted, until the blow pipes are up and the blast is on the furnace, unless the furnace is allowed to stand under natural draught.

13. Before monkey fastenings are released, or before the removal of other coolers, the pressure should be taken off or reduced.

14. Before working around explosion doors, bell rods, hangers, or before doing any work between the big bell and gas seal, see that the gas valves are closed. Be sure that the gas, escaping from the stock, is lighted. Also notify the man operating the bells.

15. Whenever a furnace is hanging badly, or is likely to slip, the man operat-

ing the snorting valve should see that the mixer valve is tightly closed before opening the snorting valve. This rule applies at casting time, if the furnace is at all likely to slip.

16. Great care should be taken in cooling and handling flue dust. Flue dust is dangerous because it is likely to fly, slide, and explode, causing severe burns. Never walk on flue dust.

17. Look out for gas. It may be found anywhere. Sometimes you cannot see or smell it. You may become unconscious before you know that gas is present. If you feel a sensation of dizziness, headache, stiff neck or weak legs, get into the fresh air at once.

18. When putting water on a furnace to cool it, stand aside to prevent being struck, in case the furnace should burn through.

19. Keep away from the valves under dust catchers and down-legs, especially when a furnace slips. There is always danger from gas.

20. Each scaleman should test his furnace whistle when he comes on duty.

21. Employees, working about casting or pig iron machinery, should wear goggles to protect their eyes from sparks and splashes of metal.

22. Keep away from cinder ladles when they are being filled, especially in wet weather.

23. Iron and cinder ladles should not be filled higher than 8" from the top.

24. Before cinder ladles are filled, they should be dried out and examined by a regular inspector.

25. Employees should be forbidden to ride on fenders of transfer or scale cars.

26. Loose scrap should not be left on the noses of hot metal ladles.

27. Molten metal will explode when it touches the ground, or a cold, damp surface. See that all bars, runners, moulds, mud guns, ladles, and shutters are dry before using them.

Open Hearths. — A suitable platform, serving as a means of escape for cranemen from spills of molten metal, should be built off the crane runway. When a furnace is shut down for repairs, all valves and slides should be padlocked, to prevent gas from being accidentally turned on. Hydraulic jib cranes should be provided with a cable, running over a sheave at the inner end of the boom, and attached to the floor at the base of the crane. This will serve to draw the runner back from over the men working at the tapping hole. When a furnace is being rebuilt, a tight plank fence should be constructed on the charging floor. This will prevent material from falling on men working in the furnace ports.

OPEN HEARTH RULES

1. Molten metal is likely to boil over, especially when the stopper of the ladle is raised for pouring. This cannot be foreseen by those in charge, therefore each workman should be watchful for his own safety.

2. Metal should not be poured into mixers while the gas or oil is turned on. Before metal is poured, gas or oil should be turned off from the mixer, and air or steam allowed to blow. This will prevent a possible explosion.

3. When breaking ingots from cars, the outer shell of the ingot sometimes ruptures, allowing molten metal to escape.

4. Before tapping an open hearth furnace, it should be reversed and centered. The first helper should see that the metal is working at the tapping hole, and inform the second helper before he starts to open the hole. If there is danger of a premature outbreak, the second helper should be warned.

5. When working on furnaces below the charging floor, be sure there is no material or object above which can fall on you. When cars are moved past the furnace, get into a position where you will not be injured.

6. When you are working on a furnace, use a scaffold which is placed in such a position that it cannot be struck by a charging car. A signalman should be stationed to stop cars before they reach the scaffold.

7. Switchmen and charging car men should see that loads are properly trimmed before moving them. Pans should be set on buggies in a proper manner.

8. Slide cars should be so loaded that lumps cannot fall off or break and drop when they become cold.

9. Do not throw any material from the charging car floor to the ground.

10. Do not break manganese on tapping platforms. It may fly, striking workmen in the pit.

11. Men, working in checkers, should be protected from falling material by means of a shelter.

12. When men are repairing a furnace, going in and out of a furnace, working on a scaffold, or on a ladder in front of a furnace, a danger sign — " Men on Track " — should be clamped on the rails at each end of the furnace. This will warn operators not to shove cars beyond the danger point.

13. When on tapping platforms, take care to avoid being struck by stirrup ladle hooks on pit cranes.

14. When ladles are being placed on, or removed from, cars, operators should keep off the cars.

15. Goggles should be worn when pouring, to protect the eyes from sparks.

16. Before tapping cinders, previous to charging, be sure there are no men in the pit in a position to be burned.

17. Moulds should be thoroughly inspected before being set on pouring platform tracks. Defective moulds, and those having a crust of clog in them, should not be used.

18. Care should be taken in capping or uncapping moulds containing soft heats. Gas frequently causes an explosion. Moulds should not be uncapped until 10 minutes after being poured. Goggles should be worn during this operation.

19. Covers should never be removed from thermit welding pits.

20. Moulds with stickers on, when being switched in narrow gauge cars, should be blocked up with wooden blocks. Brick should never be used for blocking.

Cupolas. — All platforms and runways about cupolas should be equipped with standard handrails and toeboards. The latter are important in preventing loose material from falling on workmen below. The section of the cupola, which is just below the charging floor, should be made of cast steel. This will prevent warping, keeping scrap and other material from falling through between the charging floor and the cupola. Cupolas should be provided with a grate covering, except over the space through which material is fed to the furnace. Ladles should be provided with sheet metal shields at the side where the operator stands in pouring them. This will protect him from spilled or spattered molten metal. Where the cinder from the cupola is run through tne floor, the runner should be guarded by a shield of sufficient height to prevent workmen from stepping into it.

Drop chutes on cupolas should be enclosed so far as possible, a four inch hole being ample in which to place a bar for knocking out props. Wherever practicable, props should be pulled out by means of a snatch block and cable, rather than by hand. The bottom doors and fastenings should be frequently inspected for defects.

Before cleaning out a cupola furnace, steel shields, with a bar hole, should be set up to protect the workmen when knocking out props. These shields prevent workmen from being burned by flames which might shoot out when the doors open. When relining a furnace, a screen should be placed at the top of the cupola. This will prevent loose bricks and other material from falling on the workmen.

Mud guns, for stopping tap holes, should be equipped with a funnel shaped casting to prevent workmen from kicking mud into the tap hole.

The hoist elevator should be enclosed on the unused sides to a height of 6 feet. The used side should be

equipped with an automatic gate, to prevent loose material from falling on the workmen below. The elevator should be provided with a self-releasing hinged cover. There should be a substantial grating under the head sheaves, unless the elevator is of the plunger type. The unused sides of the shaft should be enclosed with wire mesh between the floor and the charging platform. Both entrances to the elevator shaft should be provided with automatic gates 6 feet in height.

Mixers. — All mixers should be so counterbalanced that they will return unaided to the upright position, if the pressure is off the tipping cylinder. Next to the operating valve on the pressure pipe, at the front of the tipping cylinder, should be placed a cut-off valve, which will cut off the pressure from the cylinder, opening it to the discharge. The counterweight will then bring the mixer back to the upright position, not allowing it to be held back by the water in the cylinder. This valve should be used only in case of emergency. The hydraulic cylinder under a mixer should be protected with a steel plate, covered with fire brick. A safe means of escape should be provided for men working on the mixer platform. Warning bells should be installed. These should always be rung by the operator before pouring a heat.

Pouring platforms should be amply large. They should be provided with a number of exits. Platforms for operators should be so placed that the men can see the operation of their machinery at all times.

Side levers should be used for pouring steel. Steel should not be poured straight from in front of the ladles.

Crucibles. — Graphite crucibles should be frequently examined for cracks and other superficial flaws. Crucibles which are not found to be in a sound condition should not be used.

Moisture in a crucible is a great danger, when the crucible is subjected to a high temperature. All crucibles should be carefully examined for dampness. They should

always be kept in a warm dry atmosphere. They may be safely stored in an oven on the roof of a continuously operated core oven. This will prevent the absorption of any moisture. Small amounts of absorbed and trapped moisture, within the walls of the crucible, are converted into steam at high temperatures. Slight explosions then ensue which gradually weaken and fracture the crucible.

Each crucible should be properly annealed before placing metal in it for the first time. After annealing, the crucible should not be allowed to cool before it is charged, otherwise moisture may again be absorbed.

As concentrated pressure on the crucible at a melting temperature may deform, indent or fracture its sides or bottom, it is important that the crucible, when in the furnace, be set upon well prepared fuel beds, or upon level fire bricks or graphite pedestals. The bottoms of crucibles should be free from clinkers and other projections.

Metal should be loosely charged into a crucible, to prevent jamming or wedging as the metal expands, otherwise it may strain and crack its walls.

After pouring, no metal should be allowed to remain in a crucible, unless it is to be immediately recharged. If it is not scraped free from slag after pouring, "buttons" of metal will form, which strain the crucible on contracting. It is advisable to scrape the crucible, after each heat, of all slag and scrap. This secures maximum capacity.

Crucibles are often damaged by badly fitting tongs and shanks. The tools should not "pinch" the crucible when it is being lifted or poured. Tongs should grip the crucible below the bilge, avoiding the crushing of the lip. Plain ring shanks pinch the crucible least, and are safest. Rings should be thick enough to retain their shape for a long time. Tongs and shanks should be frequently examined for flaws, worn pins and rivets, and other defects.

Ladles. — Ladles should be so balanced on their trunnions as to remain erect, even when filled with molten metal. Top-heavy unstable bowls are always dangerous. On the other

hand, the bowl should not be too heavy below the trunnions. Careful balancing is essential to facilitate smooth pouring. The operating gears should be so designed that two sets of teeth are in mesh at all times. If one set of teeth breaks, the other will act as a safeguard against spilling the molten metal. Gears in the operating mechanism wear very quickly, being subject to extreme heat and cold. For this reason, they should be frequently inspected. Ladle gears should be enclosed with a removable metal casing. The gears should be so arranged on all ladles in the foundry, that the hand wheel is turned in the same direction on each one; otherwise, an operator may unconsciously turn the hand wheel of a ladle in the wrong direction, spilling the molten metal.

When being carried by cranes, monorail trolleys, and when resting on ladle buggies, ladles should be secured in the upright position by means of a latch. The lips of ladles should be so designed that the metal will flow freely in one smooth stream when pouring. They should be designed to prevent molten metal from backing up and overflowing from the ladle. Ladles are now designed with a recessed top rim, to prevent molten metal from slopping over. In case the metal slops against the side from a jerky movement, it is thus directed back to the center of the ladle.

All mixer transfer ladles should be provided with automatic alarms. A signal system should be installed between the mixer, pourer, and operator of transfer ladles. This should be used for notifying the operator when the heat is to be poured and when ladles are ready to be moved. Uncapping stands should be equipped with sliding doors, or properly railed off.

All ladle trunnions should be drilled and tested before they are placed in service.

The bail of ladles is subjected to constant wear where the crane hook engages it, being gradually weakened at this point. Bails should be replaced when they are showing signs of excessive wear.

Hand ladles should be so balanced as to return to the upright position, regardless of the amount of metal in them. The shanks should be amply strong. Hand ladles should be provided with a shield or fender to prevent the molten metal, if spilled, from slopping upon the workman. Discarded ladle shanks should be scrapped. Defective shanks should be immediately repaired. Ladle shanks should not be stored where they may be subjected to corrosion, or exposed to the weather, as they will quickly rust. Single ladle shanks should preferably be attached to the bowls. Bull ladle shanks, if detachable, should have a rigid fork at one end, and a swivel fork at the other, so that the man on the swivel end cannot interfere with the control of the ladle by the man holding the rigid end. The bowls of bull ladles should be secured to their shanks by means of iron clamps fitting over the rim. Shanks with one plain end should not be used for carrying. They do not afford a proper grip.

Ladles should be thoroughly dried before use. If at all damp when molten metal is poured into them, the metal will explode. Large ladles are usually dried by wood fires, or by drying torches. It is best to dry hand ladles and bull ladles in an oven, over special ladle heaters, or in a large core oven. In any case, they should be thoroughly heated and free from dampness.

Ladles should be inspected for cracked and thin bowls, loose rivets, eroded shanks, defective welds, imperfect balancing, defects in gear mechanism, and lack of guards on gears. A special man should be appointed as a ladle inspector. This method is safer than having each man inspect his own, as many workmen prefer to take chances, rather than adopt the safe course. The inspector should see that ladles are stored together in a dry place. Ladles with holes, cracks, or thin places in the lining, should be discarded until relined.

Carrying and Pouring. — The safety recessed type of ladles with guard fenders should be used to prevent the

molten metal from being easily spilled. The handling and pouring of ladles should be entrusted to experienced men. The bowl should be carried behind the workman, with the back of the hands facing forward. The ladle should be well balanced. Where many men pass one another to and fro, it is good practice to have them pass each other

FIG. 77
Wrong way and right way to pour molten metal. Improper and proper clothing for legs and feet.
Courtesy National Founders' Association.

on the bowl side. This prevents confusion. Collision with the bowl of a ladle does not cause such a serious splash of metal as collision with the handle. While pouring, the workman should keep his feet away from the mould, and from underneath the bowl. Bull ladles should be carried by men of approximately the same height, so that ladle handles may be naturally kept in a horizontal position. Workmen, when passing by, should keep to the right.

Where many moulds of a uniform height are to be poured from bull ladles, portable horses, which straddle the moulds, should be used. While pouring, the ladles may be placed upon these steady supports.

When filling hand ladles at the cupola from a continuous stream, the ladles should be cut into the stream from

FIG. 78
"Congress" shoes and canvas leggings for foundrymen.
Courtesy National Founders' Association.

the front side, instead of at the back. This will avoid excessive spattering. Ladles should not be filled so full that molten metal will easily slop over when being carried.

Shoes. — "Congress" shoes have become the standard for foundry work. They have no tongues, lacings, eyelets or buttonholes, in which spilled or spattered molten metal might be caught and held, thus burning through the leather into the flesh of the workman. (Fig. 78.) They

may be easily and quickly removed in case of an emergency, whereas it would be impossible to remove a lace or button shoe in time to prevent being burned by molten metal, which might lodge in some depression of the shoe. These shoes should be sold at cost to the workmen. This will induce the workmen to buy them, instead of other kinds. Employers should require their foundrymen to wear this type of shoe.

Leggings. — Almost equal in importance to "Congress" shoes are suitable leggings. Some are made of canvas, some of asbestos, and others of leather. Canvas leggings are found to be most suitable to the conditions which ordinarily prevail. It may happen in other cases, however, that asbestos leggings are a necessity on account of the intense heat.

In any case, the leggings should be so constructed as to be quickly slipped off. The "N. F. A." legging meets this requirement. This legging consists of a tapered canvas sleeve, fitted with suitable spring clasps to hold it on the workman's leg. Canvas is a cheap, light and comfortable material for this purpose. It readily sheds molten metal from its surface. The legging is held on the leg by means of two flat springs, which are enclosed in suitable pockets at the top and bottom. The springs are sufficiently flexible to allow quick removal of the legging, yet having enough tension to hold the legging securely in place. This type of legging has the important advantages of having no straps, buckles or buttons. A canvas collar, slightly drawn in, is fastened at the top of the legging. This permits a snug fit about the leg, thus enclosing the gap that would otherwise allow the entrance of molten metal. A canvas flap is attached to the back of the legging, to be tucked within the legging, covering the trousers. The whole leg is thus completely encased with canvas. One size of legging is suitable to practically any size of leg. Suitable stiffening ribs are secured inside the legging. These prevent buckling.

The combination of such leggings with foundry shoes offers complete protection to the feet and lower part of legs of foundrymen. Either may be removed almost instantly. The use of both practically eliminates serious foot and leg burns.

Goggles. — Nothing is more important for safety in the iron and steel industry than the proper protection of the eyes. Workmen should be supplied with individual pairs of goggles, suitable for the work at which they are engaged. They should be required to wear goggles in handling molten metal, roughing, chipping, grinding, babbitting, and in any other instance where the eyes should be protected. Thousands of eyes are lost through neglect of this simple precaution.

Trucks and Charging Cars. — Trucks and charging cars should be equipped with suitable guards or fenders in front of the wheels, preventing anybody from being run over by the wheels. If a workman is hit, he will simply be pushed along the track by the guard, thus preventing the wheels from crushing him. Workmen should be forbidden to ride on trucks and charging cars. Warning gongs should be placed on all cars. All gears should be encased. A plate guard, at least 3 inches in height, should be placed on both sides of the traversing carriage runway, to prevent men from placing their feet on the track. Bumpers should be placed on each traversing carriage track, to prevent the carriage running back within two inches of the end plate.

Foundry Floors. — It is important that foundry floors be kept in an orderly condition, free from obstructions in the regular paths used by workmen. Gangways should be kept clear at all times. The floor surface should be kept in an even condition. Loose articles and uneven places on the floor, or in the gangways, cause "spills" of molten metal, which result in serious burns to workmen. This type of accident is of very frequent occurrence.

Gangways should be so wide that workmen can pass

each other with safety when carrying ladles. Workmen should have clear avenues of escape from "spills" at all times. Gangways should never be used for the temporary storage of flasks, castings or moulds. Each morning before dressing down, or building up the floors, it is good practice to stretch twine lines on permanent hooks, located at the floor ends of the aisles. These lines guide the workmen in dressing down, or building up floors, and in placing their moulds. Another way is to drive 4″×4″ wooden

FIG. 79
Congested and dangerous foundry floor.
Courtesy National Founders' Association.

stakes at close intervals, showing the aisle lines. The tops of the stakes are used to show the floor level which is to be maintained, the stakes being easily removed and replaced when necessary. Workmen will not stumble over them when they are covered with sand. These stakes are also used to apportion individual floor and aisle space, thus preventing one moulder from infringing upon the floor or aisle space of another.

Moulds and individual aisles should be so arranged as to make it unnecessary for the pourers to climb over moulds

when pouring. Each mould should be readily accessible. The individual aisles should be wide enough to allow the pourer ample room when standing and pouring; also, wide enough to prevent the pourer from colliding with other workmen, flasks, partitions or posts.

Every day, before pouring is begun, each moulder should be required to clear his floor and aisles. All sledges, flask clamps, wedges, hammers, and other implements should be removed. Skimmers should be assigned a standard place. A place should also be provided for ladles when temporarily set aside. Ladles should never be placed in the aisle, even for a moment, as this may cause some passing workman to stumble. Workmen should not be permitted to throw hot castings, moulds, or sprues into the aisles. Spill troughs should not be placed in the aisles. They should be located at some other safe place. Spaces should be provided on posts, shelves or partitions for all tools. There should be a hook for every shovel and ladle shank. Double shanks should be suspended from light chains when not in use. Chain slings should be hung side by side. They should not be left upon the floor. Ladles should be stored in a separate room where they may be dried and relined. Flasks and patterns, not required for immediate use, should be placed in the flask storage yard, or in the pattern storage. Barrows, trucks, and sand boxes should be removed from the foundry, when not in use. Strong shelves should be placed about the walls upon which extras, not required for immediate use, can be stored.

Unless there is a regular place for all tools and appliances, the articles being kept there when not in use, the floors soon become dangerously congested. The foundry which is in an orderly condition is usually found to be more efficient, and to suffer fewer accidents, than the foundry in which systematic practice is lacking.

Foundry Yards. — Foundry yards should be maintained in an orderly condition. An orderly yard is safer and

cheaper to maintain than a disorderly one. The foundry yard is usually used for the storage of a great many flasks, castings, and other material. The storage of these materials in the foundry yard relieves the congestion which would otherwise obtain in the foundry.

Flasks which are stored in a systematic manner, not too high, may be easily found at any time; whereas, in a yard littered with flasks which are piled in a haphazard way, much time is wasted in looking for the desired flask.

FIG. 80
Safe and well kept foundry floor with plenty of aisle space and adequate natural light.
Courtesy National Founders' Association.

The surface of the yard should be fairly flat, to provide the proper foundation for storage piles. Smooth, level cinder path footways should be built for the safe travel of barrows, trucks, and employees. These walks should be so located that employees will use them, instead of taking shorter cuts over small piles of pig iron, scrap, or other material. Board walks are not practicable, as they quickly deteriorate or become broken.

All pits, depressed walks, or unsafe places should be protected with guard rails. All manholes should be covered.

Sand and coke bins, and other permanent bins, should be substantially built, and maintained in good condition. Weak, dilapidated bins are unsafe. Suitable bins should be constructed into which workmen should be taught to deposit old lumber, barrel hoops, discarded shovels, worn-out tools and equipment, and other rubbish, instead of carelessly throwing them about the yard where they may injure workmen.

Material should be carefully piled. No material should be stored within 6 feet of any track.

Sand Mixing Machines.--The opening to the mixing cylinder should be protected by a substantial iron rod grating, with rods spaced not farther than two inches apart. The mixer should be equipped with free swinging discharging doors. Belting and gears should be completely guarded. A tight and loose pulley should be provided. The belt shifter should be equipped with an automatic locking device.

Grinding Mill.-The tub should be completely surrounded by a circular screen guard of sufficient height to prevent anyone being crushed by the heavy rollers. The mill may be fed by a hopper through an opening in the screen. All gears, belting and the clutch should be completely encased. The clutch should be equipped with an automatic locking device.

Sand Sifters.-Sand sifters should be protected by a standard railing, equipped with a gate, placed at least 12 inches from the revolving parts. Belts should be guarded to a height of 6 feet and provided with a belt shifter which will automatically lock on and off position.

Tumbling Barrels.---Tumbling barrels have dangerous projections, such as bolts, rods, flanges, and fastenings. The barrel should be guarded with hinged cylindrical sections of sheet metal which enclose the exposed parts as shown in the accompanying figure. The sheet metal sections should rest

on a framework of angle iron, and should be properly hinged and counterweighted. The gears should be completely enclosed. The belting should be guarded to a height of 6 feet. Chain hoists, suspended from an overhead trolley track, should be provided for lifting the covers off the barrels. This will prevent many accidents from covers

FIG. 81
Sheet metal guards for tumbling barrels which are hinged and counterweighted.
Courtesy National Founders' Association.

falling upon the hands and feet of workmen. The machine should be equipped with an efficient exhaust system, which will remove all dust which would otherwise injure the health of the men. The intake is usually at one end of a hollow shaft, and the exhaust at the other. This method of removing dust prevents it from escaping from the barrel. Machines which have no exhaust system of this kind should be completely housed in dust-proof compartments. These housings should be equipped with sliding

doors, carefully counterweighted, with the counterweights enclosed. Smaller housings are often necessary, with steel roller shutters for the enclosure, instead of rising doors. The compartments and housings should be tightly built, with well fitted doors and shutters.

Guard rails may be equipped with gates which are connected to the starting lever. In this case, the machine cannot be started until the gate is closed. On the other hand, the machine is stopped by means of this automatic control, as soon as the gate is opened. This device insures that the workman will be in a safe position when the mill is running. In any case, levers should be of the positive locking type, to prevent the belt from creeping on the tight pulley, unexpectedly starting the machine.

To prevent accidents caused by a slight movement of the mill while it is being loaded or unloaded, a suitable locking device or brake should be installed, to positively lock the barrel in position. The usual method of propping the barrel with a bar is unsafe, as the bar may be kicked or jarred out of place.

Finally, the aisles in front of, and leading to, tumbling barrels, should be kept clear of obstructions.

Gas Producers. — All cleaning and explosion doors on gas pipes or mains should be hinged. Counterweights on explosion doors should be provided with safety chains, or other devices, to prevent them from falling, in case of breakage. Bar hole stoppers should be hinged. Cleaning doors on gas pipes, opening on a platform or walk, should be so constructed that they can be locked closed, to prevent back pressure of gas from forcing them open. When a producer is shut off from the main pipe, or when a soaking pit or a furnace is cut out, provision should be made so that the gas cannot accidentally be turned on again.

When working about gas producers, the danger of being overcome by gas should be kept in mind.

RULES FOR COKE OVENS

1. Employees should be forbidden to go on coal conveyors, or in galleries in coal-crushing building, gas-cooling building, coal-washing building, or any other by-product building, unless their duties require them to do so.
2. No one should be permitted to ride on transfer cars, pushers, levelers, or other machinery, without consent of the foreman.
3. Smoking, or the use of naked lights in the buildings, should be positively prohibited. Waste or grease of any kind should not be allowed to accumulate.
4. When screwing electric bulbs in sockets, in the gas-cooling or washing buildings, the power should be turned off to prevent explosion.
5. Tar should be kept off walks, steps and runways.
6. When working on top of ovens, wear clogs or canvas soles to prevent the heat from burning your feet.
7. Special tools should be provided for cleaning around and under conveyors.
8. Heaters and heater helpers should exercise care in opening gas guns. There should be no open lights or fires in the alleys when swabbing out burner pipes.
9. When taking off caps to swab the pipes, and when removing plugs in the mains to chase tar, swabmen and tar chasers should make sure that all fires and open lights are out.

RULES FOR STOVE CLEANERS

1. Stove tenders and packers should not tighten nuts on doors of stoves, tuyere caps, etc., when the stove is on blast.
2. When men are working in a stove, signs reading "*Danger, Do not Move*" — should be hung on the chain operating the cold blast valve.
3. All stove cleaners should wear eye shields.
4. When the wind is off the furnace or when the furnace is slipping badly, the foreman should order stove cleaners out of stoves. There is danger of gas from the furnace backing in the stoves and igniting.
5. When working in the bottom of a stove, cleaning checkers, workmen should stand under the arch to protect themselves from falling brick and flue dust.
6. No torches should be used at blast furnace stoves, or other places where there is gas, but the use of extension cords and protected electric lamps at these places should be enforced.

Stock Yards and Stock Bins. — Ore bridge trolley cabs should be equipped with brakes, air whistles or gongs, and with safety switches located on top of the cab. Safety switches should also be installed at each end of the bridge between tracks, to cut off all power respectively from each set of truck gears. Trucks should be provided with automatic brakes.

In handling stock from pockets, the bottoms of which are formed by drums, gates should be installed over the drums, to prevent material from falling on the car operator. Pockets should be so shielded as to prevent material, dumped from above, from running through the pocket, injuring men in the alley below.

All scale and transfer cars should be equipped with air brakes, fenders, and gongs which should ring continuously while the car is moving.

Skip pits should be so constructed that there will be ample clearance for a man on all sides of the skip car. All skip pits which cannot be entered at the bottom level should be equipped with stairs. Skip openings in stock trestles should be guarded. Skip car tracks, near the top of a furnace, should be provided with shields on the under side, terminating in a chute.

Bins, which are used for flue dust, should be provided with heavy cast iron sluice gates, adapted to quickly cutting off hot flue dust.

A sprinkling arrangement should be so installed at all dust catchers as to thoroughly wet the dust as it is emptied into cars. Operating devices for dust catchers should be provided, which will enable workmen to dump them while standing at a safe distance to avoid being burned by the hot dust. The down-legs should be low enough to prevent the dust from scattering.

RULES FOR FOUNDRIES AND STEEL MILLS

1. Workmen handling molten metal, babbitting, roughing, finishing, arc-welding, chipping or grinding, should wear goggles, masks or helmets.

2. Shields should be used when roughing or cleaning with a sledge.

3. Workmen handling molten metal should wear "Congress" shoes and leggings to afford the proper protection from burns. Shoes with eyelets, lacings or buttonholes are dangerous. Spilled or spattered molten metal will catch in these places, and burn through the leather into the flesh. Wear shoes with good stout soles, and do not allow them to wear too thin.

4. Asbestos leggings, aprons and mittens should be worn, when deemed necessary by the superintendent or foreman.

5. No more men should be allowed around ladles, when they are being

poured, than is absolutely necessary. Ladles should be properly protected by metal shields.

6. Employees, engaged in dumping ladles of molten metal, should be instructed to use care not to stand in the way of any metal, which might splash, or run out of the course in which it is intended to flow.

7. Moulds, bars, runners, etc., should be dried before using. Molten metal will explode, when it touches wet, cold or damp surfaces, or is spilled on the ground.

8. Employees should be forbidden to ride on engines, cars, overhead or locomotive cranes, or other moving bodies, except when required to do so by their duties.

9. All ropes, chains, cables, blocks, slings, and other portable appliances, used for hoisting, should be kept under lock and key, when not in use. The foreman should examine these appliances before they are given out, to insure their being in good condition. Chains and hooks should be annealed from time to time, and records kept of inspections and annealing. The hooks and chains should be numbered, so that they may be identified. The overloading of chains should be strictly forbidden. Foremen, chainmen and cranemen should be held individually responsible for the observance of this rule.

10. Chainmen should take sufficient time and care to avoid injuring their hands, when chaining or hooking. They should see that the slings are properly made and hooked, adapted to the work at hand, of sufficient strength, and that they are protected from the sharp edges or corners of material by wood, or some other yielding material. The ropes or chains should never make an angle of less than 60° with the horizontal. Chainmen should make sure that the load cannot slip, tip or overturn. Chain slings should never be crossed, when placed around a load.

11. Wire rope should be used for lashing, except where it would be likely to slip, or in case of raising light material. When lifting heavy pieces, double lashing should be provided, and where practicable, double tackle should be used. In all cases, the man in charge of the work should ascertain, if possible, the weight of the material to be hoisted. He should carefully inspect the tackle and lashing.

12. Do not take hold of the crane cable above the sheave block. Your fingers might be drawn into the block and mutilated.

13. Hold the hook, as the block is being hoisted, so that it cannot catch on anything.

14. Hookers should walk ahead of loads carried by cranes, and warn men on the floor to get out of the way of the load.

15. Jib cranes should be kept back in the bays, to prevent them from being struck by crane loads.

16. Be ever watchful of loads carried by cranes, or suspended in the air, and keep out from under them.

17. No one should be allowed to go upon an overhead crane runway, without permission from his foreman, and then not until the cranemen have been notified. Before a man goes upon a crane runway, for any purpose, provision should be made, by the foreman in charge, to stop all cranes before they reach the point where the man is working, until he gets into a place of safety.

18. Foremen should learn the safe working loads of all cranes and chains in their departments, and be careful that these loads are not exceeded. The safe capacity of each crane, in pounds, should be printed in large white letters on each side of the crane.

19. Defective ropes or cables should never be used.

20. Before giving a signal to move or hoist a load, chainmen should make sure that no one is in a position to be injured.

21. The floors should be kept in an orderly condition. They should never be allowed to become overcrowded or congested. Gangways should be kept clear at all times.

22. Do not allow material to drop on your hands or feet. Many accidents are caused in this manner.

23. Do not overload trucks. Be careful to keep your feet from under the wheels. See that the handle cannot swing around and strike you. Do not walk at the side of loaded trucks, when being moved.

24. Use great care in handling and pouring molten metal.

25. Do not go upon either ingot car, or charging car tracks, without first seeing where the car is.

26. All employees, except attendants, should be warned to keep away from gas producers.

27. Keep the flue doors of gas producers weighted or barred, to prevent back pressure of gas forcing them open.

28. Steam should not be shut off, while the gas producer is in operation.

29. Lighting gas and oil furnaces:

A. How to light gas furnaces:
   1. Make sure that all gas in the furnace is shut off, and that the draft damper is open.
   2. Put a blazing fire at gas inlet.
   3. Turn on gas.

B. How to light oil furnaces:
   1. Make sure that the air or steam valve is closed.
   2. Put a blazing fire at oil inlet.
   3. Open the oil valve a little.
   4. Turn on air or steam.

30. Dangerous gas may be found anywhere. You cannot always see or smell it. You may become unconscious before you know that the gas is present. If you feel a sensation of dizziness, stiff neck, weak legs or headache, get into the fresh air as soon as possible.

31. Men, working in pickling rooms, should watch the movements of the cranes, in handling stock to and from the vats, to avoid being splashed with acid. They should wear goggles to protect the eyes from scale and acid.

32. Whenever repairing or oiling a machine, each boss of a crew, and each independent man, should attach his own padlock to the switch, irrespective of whether he finds the switch already locked or not.

33. Shearmen should use care not to get their hands too near or under the knives of the shears, corrugating machines or any other similar appliances, even when not in operation. The knives might drop unexpectedly.

34. When shearing bars, or other material, take care that the end does not

fly up and strike you. Never remove guards, placed in back of shears, which keep the material from flying.

35. The shear knife should be down, before anyone is allowed to change the gauge.

36. When rolling bars, which run off the end of the table, a man should be stationed near the end to warn persons passing by.

37. Never put a bar into the next set of rolls, until you are sure it is over the safety post. Be sure that the safety post is in position, and securely fastened to the floor.

38. Take care that the bars, coming through the rolls, do not strike your hands or feet.

39. Before moving tables, or other machinery, make sure that no one is in a position to be injured.

40. Do not go under a table unless you have notified the operator, and blocked the table.

41. When pulling bars from the pile to the table, exercise great care not to pull bars that will cause other bars to fall on you.

42. Do not step on table rolls. They may be started at any moment.

43. Watch out for table dogs. Do not step in table dog slots.

44. When working around rolls, especially when wearing gloves, be careful that your hands are not caught by the rolls.

45. Under no circumstances, put your feet in front of the passes, while the mill is running.

46. Spindles should be securely boxed at all times.

47. When operating bulldozers, do not stand where bars on tables can move along and strike you.

48. Do not go under a saw frame, unless you have notified the operator, and blocked the saw.

49. Pull out safety switch, and stop machinery, before going under conveyors.

50. Use great care in operating hammers, bulldozers, punches, shears, etc., and be especially careful not to trip them unintentionally.

51. When passing through the mills, go by the regular passages, subways or overhead walks.

CHAPTER XVII

HANDLING AND STORING MATERIAL

MACHINERY, which is used to hoist and carry loads, requires constant care and frequent inspection to insure safety. The provision of adequate safeguards and safety devices, in this connection, is especially important. There is always danger that suspended loads may fall, with the possibility of injuring workmen beneath them. Where cranes are used to carry molten metal, there is increased danger from spills, which might cause serious and fatal burns. There is a multitude of other conditions which may exist or arise, producing many other accidents. These can mostly be avoided, however, by the use of suitable safeguards, careful operation, and frequent and thorough inspection.

Electric Traveling Cranes. — The structural work of cranes should be of medium open hearth steel. No cast iron should be used except for bearing caps, collector shoes, trolley collector hinges, and arm and collector supports. Steel should be used for all other parts. Cast gear covers, however, may be of malleable iron. No wood or other combustible material should be used in the construction of any crane.

All parts which are subject to impact and rough usage should be amply strong. Journals and shafts should be of sufficient size to bring pressures and deflections within safe limits.

Gears, drums, blocks, hooks, shafts, girders subject to dynamic stresses, and other parts should be designed with a factor of safety of at least 10, based on the ultimate strength of the material used. Ropes with a factor of

safety of less than 10 should not be used. If the crane is used to carry hot metal, the factor of safety for ropes should be increased at least 25%. Crane girders, which are not subject to dynamic stresses, should be designed with a factor of safety of not less than 5.

All bolts should be of the through type. No studs or cap screws should be used. Bolts should be secured from turning by means of lock nuts or lock washers.

Wheels should be keyed to their shafts, and gears should be keyed to the hubs of wheels. Track wheels should be of rolled open hearth steel. Wheels and axles should be of sufficient diameter, and designed to prevent an excessive load on any one bearing. All gears, couplings, keys, and other dangerous parts, should be completely guarded.

Stairs with hand rails should be used, wherever possible, in preference to ladders. Footwalks, with hand rails and toeboards, should be placed the entire length of the bridge on both sides, and across both ends of the trolley at right angles to bridge walks, but they should not telescope over end carriage. A footwalk should pass underneath and around, instead of over the bridge motor. There should be a clearance of 6′ 6″ between the floor of the walk and overhead trusses or other structural members. Footwalks should be substantially constructed of steel, and rigidly braced. Floors and walks should be built solid of checkered steel plate.

The operator's cage should be entirely constructed of fireproof material. It should be enclosed to a height of 3′ 6″ above the floor with sheet steel or wire mesh. The cage should be equipped with an approved foot- or hand-operated gong. Each hot metal crane should be provided with a sheet iron closet, lined with asbestos, which will afford a crane operator safe refuge in case of emergency. The cage should be constructed to protect the operator from spills of hot metal. A safe and convenient means of escape should be provided from the cage to the footwalks and bridge girders. The floor of the cage should be ex-

tended on the entrance side to form a landing at least 15 inches wide. This should be equipped with a substantial handrailing and toeguards. Hot metal cranes should be provided with a sheet metal shield, placed 6 inches below the bottom of the floor, to protect the operator from intense heat.

Each switchboard should be enclosed in an asbestos lined steel closet with a swinging door that can be latched. The switchboard should be located at the rear of the cage. A circuit breaker should be installed which will open automatically, if the current fails, remaining open until closed by the operator. A main line switch, in addition to one on the crane switchboard, should be mounted above the cage where it can be conveniently reached from the footwalk. This switch should be so constructed that it can be locked in the open position. Two pilot lamps should be provided. Rheostats and resistance units should be protected from accidental contact or mechanical injury by suitable enclosures, provision being made for ventilation.

Suitable brakes should be provided for the hoist and bridge travel. There should be two brakes for each hoist, at least one of which should be an electrical one. Magnetic brakes should be encased, to prevent parts, which may become loose, from falling to the floor. A footbrake should also be provided. Each brake should be capable of stopping a full load at double speed, without the aid of other brakes.

A limit switch should be provided for each hoist. It should be tripped directly from the hoist block or hook, and not through screw contacts. A dynamic brake should be used to check the speed of the motor.

Special flexible plow steel cable, consisting of 6 strands, 37 wires to the strand, should be used for hoisting. Chains should not be used. Cable which is used on hot metal cranes, being subjected to excessive heat, should have a core of soft iron instead of hemp. The diameter of hoist drums and sheaves should be at least thirty times the

diameter of the cables. At least two full turns of cable should be wound on the drum when the hook is at the lowest limit.

The hook block should be of an approved type, so arranged that it can be hoisted without twisting. The sheaves should be provided with a cable guard, to prevent the cable from running out of the grooves. Provision should be made to prevent the load from falling, in case the block pin should break.

Steel spring bumpers should be placed at the ends of the track. Both truck wheel and trolley bumpers should be fastened to the girders instead of the rails. They should be at least $\frac{1}{2}$ the diameter of the truck wheel in height.

Truck fenders, extending below the top of the rail, and projecting in front of all bridge and trolley track wheels, should be rigidly attached to the carriage or end frame. These should be shaped plow fashion, so as to push, and at the same time raise, any part of a person's body..

Heavy safety lugs or brackets should be placed on trolley frames and end carriages to limit the drop to one inch or less, in case a wheel or axle should break. A capacity plate, showing the rated safe capacity of each hoist in pounds, should be placed on each girder. This should be plainly legible from the floor. Trolley frames should be completely floored over. Pads should be provided for use with jacks and wedges when changing truck wheels. Cranes and cables require adequate lubrication to avoid excessive wear.

A system of frequent and regular inspections and tests is an absolute necessity. There are many things in connection with crane equipment which may become defective or out of adjustment, such as loose bolts; loose set screws; loose keyways; hot bearings; worn wheel flanges; defective cables, sheave grooves, and gear teeth; flats on wheels; spreading and creeping of rails; settling of the runway; loose and uneven rail joints; clogged oiling devices; unadjusted motor brushes, limit switches, and many

other defects. These conditions can only be revealed by careful inspection.

Daily tests should be made of limit switches, brakes, and other parts.

RULES FOR ELECTRIC CRANE OPERATORS

1. Because of the nature of their important work, cranemen are in a position to help safety conditions and prevent accidents, in some respects, better than anyone else in the plant, and their earnest co-operation is necessary. The position calls for skill and watchfulness, and a craneman's freedom from accidents will be a factor in estimating his ability and success. While it is important to get the work done, it is more important to prevent accidents. Cranemen should take enough time in making crane movements to avoid accidents.

2. Many of the worst accidents have occurred from hooks catching in objects after they have been unhooked; or from cranemen raising loads before they are securely hooked, or the chainman's hands are free; or from raising the hooks before the unhooking is finished. These are some of the most important things that cranemen should guard against.

3. Cranemen should enter and leave cranes by special access platforms. When necessary to use ladders in getting on and off cranes, never carry any material up or down. A hand line should be used.

4. Keep the crane well cleaned and oiled, and in good working order, and report immediately, if necessary, and at least promptly after being relieved from duty, by written report, any needed repair on any part of the crane equipment. Do not fail to report anything that is out of order, or any guard that has not been properly replaced.

5. While on duty, stay on the crane in readiness for orders until relieved by another craneman, unless excused by the proper foreman. Never sit down while operating the crane.

6. Never allow men (except crane inspectors) to ride on crane load, trolley, cage, or on crane. Do not move the crane until such riders get off.

7. Do not place a load in an unsafe place, nor move a load unless the hitch is safe; and if the load exceeds the capacity of the hoist, call upon your foreman for instructions.

8. Keep a careful lookout for any flagman who may be stationed for the purpose of protecting the workmen on or near the runway.

9. Under no consideration, permit the crane to bump into another crane.

10. Do not allow the crane to bump against the buffers at the ends of the track.

11. Sound the foot-gong on starting, and use it regularly as an alarm while carrying loads. Under no circumstances, carry any loads over men on the floor, or over moving cars.

12. Do not move the crane, or lift or lower a load, except upon a hand signal from the one man in charge. Never move a load while swinging. Before starting to hoist, place the trolley over the load to prevent the load swinging against workmen, as it is being raised.

13. Cranemen should be cautioned that striking jib cranes, or other objects will be considered as gross carelessness, and will render the craneman subject to discharge.

14. When dumping sand buckets in cars, the craneman should lower the bucket as far as possible. If the bucket does not freely empty, it should not be racked against the side of the car, but it should be rolled up lengthwise in the car.

15. No "horseplay" should be permitted between craneman and chainman.

16. Cranemen should be forbidden to smoke, eat or read, while the crane is under the direction of a foreman on the floor.

17. Turn the controller to the "off" position before closing the main switch, and open the main switch before leaving the crane cage. The safety switch should always be opened and padlocked, and a danger card attached, when oiling, cleaning or repairing. Do not permit anyone to work on the crane until these precautions have been taken.

18. Whenever the safety, or main switch, is found open, do not close either, until absolutely sure that no one is on the crane or crane runway.

19. When anyone is injured, in any way, through the instrumentality of a crane, the crane operator, at the time of injury, should make a full written report to his foreman, and also a verbal report to the foreman in charge of the floor, when he is relieved.

20. Cranemen should follow signals of chainman, if not receiving instructions from the foreman on the floor.

21. Loads should not be moved until a signal is received from the man in charge of the floor. Great care should be used in watching the chaining and hooking, to see that the chainman's fingers are not caught.

22. Always try a load, to see if it is securely hooked, before starting away with it. Be sure that the hook is placed at a sufficient height above the load, and that the ropes, cables or chains of the sling do not make an angle of less than 60° with the horizontal.

23. When handling heavy loads, particularly molten metal, tes the hoist brake, after load has been lifted a few inches, by throwing the controller to the "off" position. If the brake does not securely hold the load, do not move the crane until it has been repaired or adjusted. Exercise great care in carrying loads with magnets, especially in wet weather.

24. Never drag slings, chains, hooks or loads along the floor. See that they are high enough to clear all obstacles. Dangerous side pulls should be forbidden.

25. Do not run blocks too high. When the limit switch is broken, report at once to the foreman. Test the limit switches each turn.

26. Never allow load to descend rapidly.

27. Do not suddenly throw controller to full "on" position. Move the controller step by step, and allow the motor to gradually speed up. If compelled to reverse controller, to stop the crane, reverse on the first point only.

28. If the controller should stick, the switch should be pulled out to prevent damage while fixing the controller.

29. Crane operators should inspect their cranes thoroughly at least once each turn, and immediately report any unsafe conditions.

30. When the crane is down for repairs, oil the crane and assist repairman.

After completion of any work, make sure that all guards have been replaced, and that all gears are properly covered. Report the absence of any guard. Keep all loose material, bolts, nuts, etc., off cranes. See that all tools are put in their proper place.

31. When repairs of any consequence are being made on the crane, it should be isolated from others by temporary stops to be attached to the rails, or by a special flagman.

32. See that all windows are closed in case of rain. Keep a fire extinguisher in the crane cage at all times, and know how to use it.

33. Never use profane or abusive language to workmen on the floor. Never throw anything at them.

34. When working on the hoist, and removing armatures, shafts, etc., be sure to have the burden-block as low as possible.

35. If the power goes off, all switches should be pulled out, and the controller moved to the "off" position. As soon as the pilot lamps light up (when the power is on again), the motors may be started.

36. Crane operators should keep a strict lookout, at all times, for anyone who may be working on or about the cranes, or crane runways, and for any other obstruction. Where two or more cranes are operating on the same runway, each crane operator should be on the lookout at all times for the other.

37. When repair work is being done on or about crane runways, the craneman should not operate the crane before he has had explicit instructions from a person in authority in that department. He should also have a clear and distinct understanding between the cranemen, and the employees making such repairs, that the crane is going to be operated. He should not move the crane until the cranemen, and the employees making repairs, have placed themselves in a safe position.

38. Avoid being reckless or careless.

39. The best crane operators should be first considered for advancement. Men are, therefore, urged to do their work well; co-operate with the men on the floor, and win their confidence and good will; keep cranes clean; run them so as to require least repairs; keep them in repair at all times; and promptly report anything that is out of order.

Locomotive Cranes. — An iron guard should be placed at the end of the boom, through which the cable can run. The opening should be small enough to prevent the thimble on the cable from coming in contact with the sheave wheel. The truck bed should be equipped with a hinged guard, which, when extended, will prevent anyone from being caught between the boiler and the truck bed.

Each locomotive crane should be provided with automatic couplers. These should be so placed on an extension, when necessary, that there will be sufficient clearance between the end of the boiler and the car to be coupled.

Each crane should be equipped with outriggers and rail clamps. Water glass gauges on boilers should be provided with suitable guards, preferably of wire-glass.

Indicator pointers, showing the safe load for any angle of the boom, should be provided. An electric indicator should be installed to warn the craneman in case the crane should tip. All gears should be completely enclosed. A "DANGER — KEEP OFF" sign should be placed on both sides of the cab. There should be a clearance of at least 18 inches between the bottom of the boiler and the truck frame.

RULES FOR LOCOMOTIVE CRANE ENGINEERS

1. Locomotive cranes should not be moved, except upon a signal from an authorized signalman. This signalman, if not a regular switchman, should be appointed by the superintendent of the department in which the crane is working. When a man is regularly employed on a crane as switchman, he should be the signalman.
2. Locomotive cranes should not be swung across a railroad track, or into such position that cars, moving on that track, would strike it, until the crane engineer and the signalman have made sure that cars are not being moved on that track. If there is danger of cars moving along tracks, set block to protect the crane during the day, and lights at night.
3. No one except the switchman or signalman should be allowed to make a coupling or switch.
4. Before hoisting, see that the rail clamps are properly fastened to the rail.
5. Do not allow anyone to ride on the truck frame.
6. See that all outriggers are in place, and properly blocked. If the crane is not protected with outriggers, block it up, wherever there is danger of tipping.
7. See that the boom is not too low, but when traveling around the yard, be sure it is low enough to clear all wires.
8. Do not allow anyone to ride on the crane.
9. When traveling, do not carry excavating buckets on the boom.
10. When swinging boiler of crane, watch out not to catch anyone between the boiler and truck.
11. Examine your crane every turn for defects, or conditions likely to cause any accident, and make a written report on blanks provided.
12. Crane engineers should use their best judgment at all times. They should be held responsible for the machine, and the safety of the men working under them.

Monorail Systems. — Unlike ordinary traveling cranes, which are strictly limited to one straight run, a monorail track can be run from one department to another in the

same building, or from building to building, through doorways, passages, and around curves. It can be supplemented by various branch tracks, being joined thereto by some form of track switch.

The safest form of a track switch for this purpose is one with a fixed tongue, which has no moving part. (Fig.

FIG. 82
Fixed-tongue switch for monorail track.
Courtesy Shaw Electric Crane Company.

82.) The great advantage of this type of switch, as compared to the old fashioned moving-tongue track switch, is that it does not have to be set for the desired direction of travel, that trolleys can run through it in all directions without stopping, and that there are no open ends of track to be guarded. It thus avoids the serious danger, ever present with a moving-tongue track switch, of the trolley brushing off the guard and falling to the ground, seriously injuring the operator and others below.

Fig. 82 shows a cast web type of safety fixed-tongue track switch. It is a rigid, self-contained structure, comprising two massive steel castings, which are clamped together at a planed joint of the tongue-and-groove form by means of four large bolts, of which only two can be seen in the cut.

The operation of steering the trolley through the switch is as follows: On approaching the switch at which the operator desires to run from the main track to the spur track, he pulls a steering lever, which is located on the trolley, near the controllers. This raises a horizontal roller to a position in which it engages a curved rib on the under side of the central switch-tongue. It thus swivels the leading truck, thereby diverting it to the spur track. By a positive and very simple means, which is not dependent on the operator, the trailing truck is also guided to the spur track. No steering is necessary to return from the spur track to the main track, nor to run through the switch on the main track in either direction. This type of switch is a great improvement over the old style moving-tongue track switch.

The monorail trolley should be equipped with a limit switch to prevent overhoisting, and also with curved buffers, forming a suitable guard in case of collision with other trolleys. A cage and seat should be provided for the operator. The trolley should have both a motor and load brake and also a foot brake for the travel motion.

Derricks. — Derricks should always be stayed by at least 6 guy ropes, securely fastened and symmetrically placed. The ropes should be of sufficient size and strength. At least three clips should be used in making a fastening. Where the rope is placed about a rock, or a wooden post, the sharp edges should be covered with burlap. It is important that the derrick be securely anchored. The foot of the mast should be carefully mounted upon a substantial foundation.

The turn sheave should be made of soft steel, and not

of cast iron. If made of the latter, it might be broken by falling rock or by other blows.

Sheaves should be so designed and placed as to prevent the cables from running out of the grooves. Two sheave blocks should never be placed at the top of a mast; only one should be used at this point. Two sheave blocks might become crossed if the boom were lifted too high. This would cause the cables to wear through the cheek plates, finally so weakening the cables that they would break. Sheaves should be inspected for broken or cracked flanges. If broken as far as the groove, the cable might be quickly cut by the sharp edges.

The boom should not be subjected to excessive stresses. If cracks occur in a wooden boom, or if it shows signs of weakness, it should be immediately reinforced or replaced. The pin which supports the boom at the base of the mast should not be allowed to become seriously worn. A boom should never be used when it has become dangerously weakened.

All parts of derricks should be frequently and carefully inspected by a competent rigger. Proper lubrication of wearing surfaces is important. Cables and guy ropes should be covered with a suitable dressing to prevent undue corrosion. Gears on hoists should be completely covered. There should be at least two turns of the cable about the drum when the hoistblock is at its lowest limit. Each hoist should be equipped with an emergency brake, foot brake, and pawl. Brakes should be kept in careful adjustment to insure their positive action at all times.

There should be a definite system of signaling. This is especially important where the hoistman cannot see the hookman or the load. Instead of depending upon whistle signals, it is safer to station a signalman where he can watch the hooking, and at the same time give motion signals to the hoistman. Hoistmen should use great caution, having their machine under perfect control at all times. Careful, experienced men should be selected for this duty.

None but skilful and responsible men should be given charge of a hoist.

Hoisting. — Foremen should know the safe working strength of chains, ropes, hooks, and cables, and their proper use and application when used as slings. All portable chains, ropes, cables, hooks, and other accessories should be kept under lock and key when not in use. When issued, the foreman should always personally inspect the sling, making sure that it is of sufficient strength and adaptable to the work at hand. All slings, hooks and accessories should be provided with number plates. A record of the number, size, grade, date of purchase, condition, tests, and dates of inspection should be kept in the office. In the case of hooks and chains, the record should contain the dates of annealing.

An examination of all hoisting equipment should be made at least once a week by a regular inspector. He should record the condition of the equipment, and the date of inspection, in the office files. Defective hoisting equipment should be removed from the shop. If discarded, it should be so damaged that it cannot be again used by mistake.

Wherever possible, the use of chains for hoisting purposes should be avoided. They are apt to kink, if carelessly placed about a load, suddenly straightening out when the load is lifted. Thus they are often broken, causing injury to workmen. Frequent and excessive strains cause so-called crystallization of the metal. This serious condition cannot be readily detected by inspection. Flaws and surface wear are apt to be overlooked. The welds may be insecure. In this connection, it is well to remember that a chain is no stronger than its weakest link. Only the best hand made, wrought iron, tested chains should be used. The chains should be periodically tested. Chains, hooks, and accessories, if continuously used, should be annealed every two or three months. They should be heated to a dull red temperature of about 525 degrees C.

(979 F.), and then cooled in ashes. Actual annealing does not take place at this temperature, but the metal is sufficiently heated to remove the structural strains without softening the metal, which is all that is desired. A very slow process of cooling renders the metal too soft to withstand much wear. Chains should never be twisted or crossed when placed about a load. They should be covered with oil to prevent rusting.

Wire rope slings are far preferable to chain slings. They can be used in most instances in lieu of the latter. Wire rope has the advantage that its dependability can usually be readily ascertained from inspection. Excessive wear or weakness is clearly shown by worn and broken wires; whereas, the reliability of chains remains a more or less unknown quantity. Plow steel rope of 6 strands, 19 wires to the strand, with a hemp core, should be used. A soft iron core should be used where the cable is exposed to intense heat. Rope with 37 wires to the strand is even more flexible and durable than the former. All slings of the same size should be of equal strength, as a workman cannot usually discriminate between different qualities of metal. Wire rope should never be sharply bent at any point. This would cause a serious weakness. When inspecting a wire rope, it is advisable to partially untwist it at several places, permitting the inner wires to be examined. The inner wires may be seriously broken before any outer indication is shown. Wire ropes should be properly lubricated, and covered with a suitable dressing to prevent corrosion.

Manila rope, if used, should consist of the best quality long fiber hemp. It should only be used for comparatively light loads. It is much weaker than wire rope, and deteriorates if exposed to moisture. Manila rope is easily cut, and for this reason, it should never be looped with wire rope.

Slings should be carefully and symmetrically placed about loads, proper hitches being made, so there will be no opportunity for the load to slip or tip. The slings should be

protected from the sharp edges of objects which are to be hoisted, by means of soft wood, or some other yielding material. Two or more slings should be used on heavy loads. The stresses in the slings should be equally distributed. The slings should be long enough to leave a safe distance between the load and the hook. If short slings are used, the stresses are greatly increased. Members of a sling should never make an angle of less than 60° with the horizontal.

Tables, showing the loads which can be safely lifted by slings of several types and various sizes at different angles of the members, should be placed at conspicuous and convenient places, especially at chain racks and supports for slings, and also near cranes. The following table, prepared by the National Founders' Association, indicates the loads which can be safely used for various sizes of ropes and chains at different angles:

Safe Loads for Ropes and Chains (In pounds)

Caution: When handling molten metal, wire ropes and chains should be 25% stronger than indicated in table.

Note: The safe loads in table are for each single rope or chain. When used double or in other multiples the loads may be increased proportionately.

	Dia.	When used straight	When used at 60° angle	When used at 45° angle	When used at 30° angle
Plow Steel Wire Rope	3/8"	1,500	1,275	1,050	750
	1/2"	2,400	2,050	1,700	1,200
	5/8"	4,000	3,400	2,800	2,000
(6 strands of 19 or 37 wires)	3/4"	6,000	5,100	4,200	3,000
	7/8"	8,000	6,800	5,600	4,000
	1"	10,000	8,500	7,000	5,000
If crucible steel rope is used reduce loads one-fifth	1 1/8"	13,000	11,000	9,000	6,500
	1 1/4"	16,000	13,500	11,000	8,000
	1 3/8"	19,000	16,000	13,000	9,500
	1 1/2"	22,000	19,000	16,000	11,000

	Dia. of iron	When used straight	When used at 60° angle	When used at 45° angle	When used at 30° angle
Crane Chain	1/4"	600	500	425	300
(Best grade of Wrought Iron, Hand-made, Tested, Short Link Chain)	3/8"	1,200	1,025	850	600
	1/2"	2,400	2,050	1,700	1,200
	5/8"	4,000	3,400	2,800	2,000
	3/4"	5,500	4,700	3,900	2,750
	7/8"	7,500	6,400	5,200	3,700
	1"	9,500	8,000	6,600	4,700
	1 1/8"	12,000	10,200	8,400	6,000
	1 1/4"	15,000	12,750	10,500	7,500
	1 3/8"	22,000	19,000	16,000	11,000

	Dia.	Cir.	When used straight	When used at 60° angle	When used at 45° angle	When used at 30° angle
Manila Rope	3/8"	1"	120	100	85	60
	1/2"	1 1/2"	250	210	175	125
	5/8"	2"	360	300	250	180
(Best Long Fiber Grade)	3/4"	2 1/4"	520	440	360	260
	7/8"	2 3/4"	620	520	420	300
	1"	3"	750	625	525	375
	1 1/8"	3 1/2"	1,000	850	700	500
	1 1/4"	3 3/4"	1,200	1,025	850	600
	1 1/2"	4 1/2"	1,600	1,350	1,100	800
	1 3/4"	5 1/2"	2,100	1,800	1,500	1,050
	2"	6"	2,800	2,400	2,000	1,400
	2 1/2"	7 1/2"	4,000	3,400	2,800	2,000
	3"	9"	6,000	5,100	4,200	3,000

Hooks should be forged and of the proper design. Laminated steel hooks are preferable for heavy loads and for hot metal cranes. Cast steel hooks are undesirable. Hooks should be properly annealed, and never tempered or hardened. They should bend slowly and gradually if overloaded, thus giving sufficient warning. They should be provided with handles to lessen the danger of chainmen injuring their hands when hooking. (Fig. 83.) Shackles, eyebolts, sheave blocks, clamps, and other accessories should receive the same care and attention as hooks, ropes, and chains.

FIG. 83
Safety crane hook with automatic lock incorporated in handle.
Courtesy Brown Hoisting Machinery Company.

Safety clamps and slings should be used wherever safety and circumstances demand their use. (Fig. 84.) The clamps should grasp material by means of a positive leverage, the greater the load the tighter the grip. The face of the dogs should be corrugated, to afford additional protection against slipping.

Fig. 85 shows an automatic shackle which is used in lieu of a hook for hoisting loads. This automatic shackle is employed where frequent lifts are made. It saves considerable time in attaching and detaching loads. Unlike a hook, there is no point which can catch obstructions. The shackle is attached to the load by simply dropping it over a rope, a ring, or a chain, as the case may be. The load is released by pressing the dogs upward as the load is detached. These dogs drop into place by means of gravity. This automatic shackle can be so made that it will not become detached from the load when the hoisting member is slack; or, it can be so designed that it will detach itself from the load whenever the hoisting member does become slack.

Sheaves, over which wire ropes pass, should be of sufficient diameter to avoid undue bending of the rope.

FIG. 84
Automatic safety clamps (patented).
Courtesy Never-Slip Safety Clamp Co., 141 Bdwy., New York, N. Y.

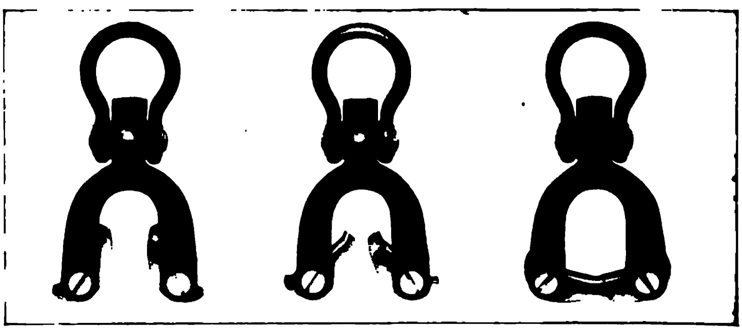


FIG. 85
Automatic hoisting shackle.
Courtesy Yale & Towne Mfg. Co.

Sheaves of too small diameter cause the wires to break prematurely. The grooves should be of the proper size

and shape to properly accommodate the rope. The surface of the grooves should be perfectly smooth. Each sheave block should be provided with a cable guard to prevent the cable, when slack, from running out of the groove. Provision should be made to prevent the load from falling in case the block pin should fail. A warning sign "KEEP FROM UNDER THE LOAD" should be painted in white upon each hoist block.

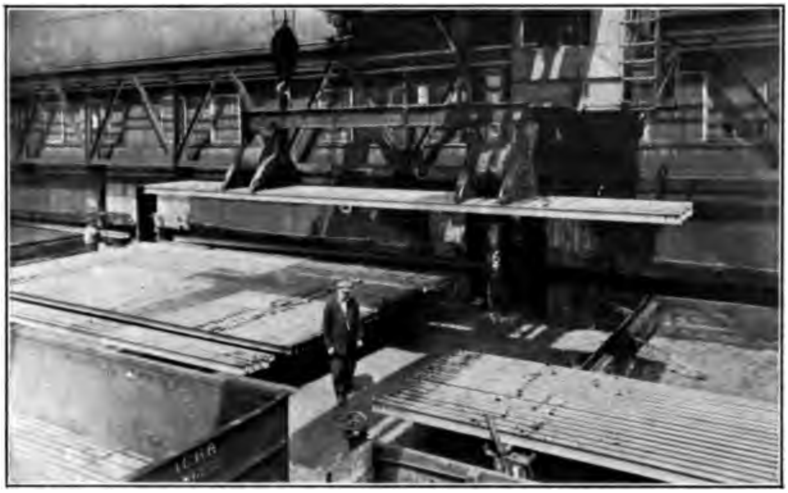


FIG. 86
Dangerous practice of standing under a suspended load.
Courtesy Illinois Steel Company.

Workmen should be constantly cautioned to keep from under all suspended loads. (Fig. 86.) For further rules regarding hoisting, reference should be made to Rules for Electric Crane Operators and Foundry Rules.

Conveyors and Elevators. — Footways, alongside of belt conveyors, should be equipped with standard hand rails and toeguards. Elevator boots should also be properly protected with hand rails and toeguards. There should be a clearance of at least 2½ feet on all sides of the machinery in the boot, and at the top of the elevator. All gears and

sprockets should be completely enclosed. Chutes at the top of conveyors or elevators should be guarded with hand rails and toeboards. All parts of machinery and equipment should be carefully inspected at regular intervals.

Docks. — Footways and bins should be guarded with hand rails and toeboards. All gears on machinery should be adequately covered.

Unloading bridges should be equipped with some form

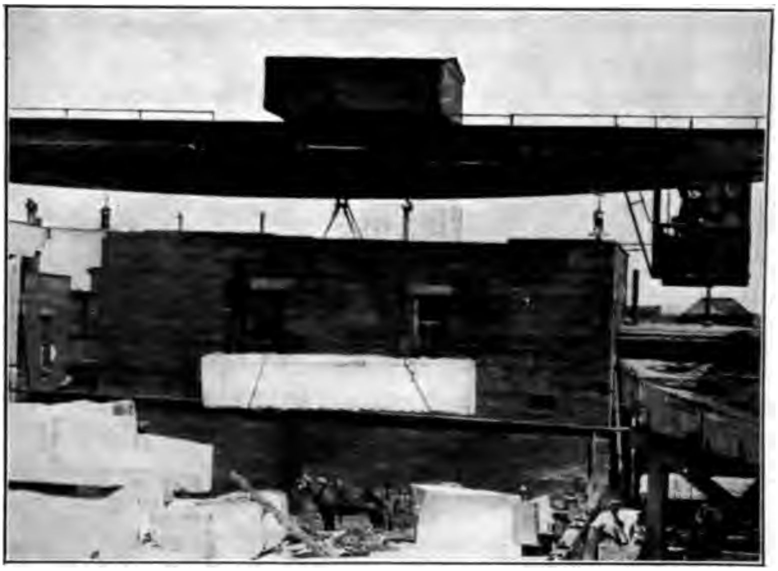


FIG. 87
Dangerous practice of riding on a suspended load.

of automatic skew-limit device, to prevent the bridge from skewing too far from the pier, as might happen if the operator lost control, or in case of a violent windstorm. If skewed beyond the safe limit, the bridge would topple over and fall. An electrical automatic skew-limit device is preferable. In this case, if the bridge is skewed to the safe limit, the mechanism will shut off the power for moving the bridge. At the same time it will shut off the current to solenoid disc brakes, allowing powerful springs

to set them. This prevents the armature of the driving motor, to which the wheels are geared, from turning. The bridge is thus effectively kept from skewing beyond the safe limit.

RULES FOR DOCKS

1. Keep out from under ore handling machinery, and from ore or broken parts of machinery which are likely to fall.
2. Keep away from cables which are used to secure boats to the dock. If the cable should break, the flying ends would be likely to strike you.
3. When working in a boat with the unloaders or grabs, get into a place of safety when they are raised and lowered.
4. No one should be permitted, under any circumstances, to ride out of a boat on an unloader. Before moving a car or an unloader, make sure that no one is in a position to be injured.
5. No one should be permitted to operate unloaders or transfer cars, unless instructed by the foreman.
6. Keep away from the electric power rails along the wall of the unloaders.
7. Operators of bridges should be instructed never to leave the bridge unless it is blocked and clamped.
8. Transfer car and bridge operators should exercise care to avoid collisions between the bridge grabs and the transfer car.
9. After unloading cars, trestle men should see that all loose material is removed from the trestle.
10. Never go into a bin to poke around ore, rock, etc., without notifying the foreman. A rope from above should be tied around your body.
11. Keep off the track on which the transfer car runs.
12. Do no oiling, cleaning, or repairing while the towers are in operation.
13. When necessary to work on machinery, open the switch and lock it, thus shutting off the power.
14. If necessary to work on the trolley line of transfer cars, shut off the current.
15. No one should be permitted to ride in the cab with the operator of the transfer car.

Storage. — Many accidents occur through careless methods of piling, unpiling, and storing material. Material should be systematically stored and piled. The piles should be secure, and unable to topple over or collapse. (Fig. 88.)

Great care should be taken in piling lumber. Planks should be cross tied at frequent intervals, to avoid the possibility of the pile collapsing. It is also necessary to use great care in unpiling lumber. Foundations for piles should be substantial, and proper sills provided.

In piling brick, the following rules should be observed:

(*a*) Except in brick sheds, brick should not be piled higher than 7 feet.

(*b*) The pile should be tied at every tier with alternate courses of headers and stretchers.

FIG. 88
Unsafe storage of lumber.
Courtesy Northern Furniture Company.

(*c*) When the pile is over 4 feet high, it should taper back, from a point 4 feet high, one inch to each foot.

(*d*) In unpiling, the taper should be maintained.

(*e*) Under no circumstances, should brick be piled, for storage purposes, on scaffolds or runways.

(*f*) Tie strips of wood should be inserted wherever necessary.

(*g*) Foremen, in charge of piling brick, should be held individually responsible for the safeness of the piles.

In piling cement, the following rules should be observed:

(*a*) Cement should not be piled more than 10 bags high, except in storage built for such purpose.

(*b*) The first four end bags should be cross tied in two separate tiers up to the fifth bag, where a step back, of one bag in every five bags, should be made. Beginning with the fifth bag, only one cross tier is necessary.

(*c*) The back tier, when not resting against a wall of sufficient strength to withstand the pressure, should be stepped back, one bag to every five bags, the same as the end tiers.

(*d*) In storage, when piled between and against walls of sufficient strength to withstand the pressure, no cross tiers nor step backs are necessary; but bags should be piled with a slight incline against the back wall, the height depending upon the strength of the wall.

(*e*) Cement bags, in outer tiers, should, in all cases, be piled with the mouth facing the center of the pile.

(*f*) When cement is removed from a pile, the length of the pile should be kept at an even height, and necessary step backs, every five bags, should be taken care of.

(*g*) All foremen, in charge of piling cement, should be held individually responsible for the safeness of the piles.

Flasks, castings, and other material, should be piled in a safe and careful manner, and not so high that the piles will be likely to fall.

Plate moulds, when piled cribbing fashion, should be piled not exceeding 12 high. When piling other moulds, the pile should not exceed 5 moulds high. Each tier should contain at least one less mould than the tier below. Each tier should be locked or blocked, to make the pile secure. Moulds with butts, or stickers, or any unevenness of bottom, should not be left in a vertical position on the ground.

Where space permits, ingots should be piled the same as moulds, or may be piled cribbing fashion, if not over 5 tiers high. Where possible, ingots should not be left to stand in a vertical position, unless proper barriers or supports are provided.

Rolls and pinions should only be piled in racks.

Pipes, rods, and bars should be stored in substantial racks. Nuts, washers, bolts and similar articles should be stored in boxes, when on shelves, to prevent them from falling. Patterns, pulleys, and wheels should be stored in racks or upon center poles.

Storage places should be kept in an orderly condition. Aisles should be kept clear of all loose material. Congested conditions should not be allowed to exist.

CHAPTER XVIII

CONSTRUCTION WORK

CONSTRUCTION work, at best, is a hazardous occupation. Workmen are constantly subjected to inevitable risks. Many of the dangers can, however, be eliminated or greatly diminished by observing proper precautions. The average contractor is often obliged to rush the work to complete a job in a given length of time; otherwise, the work, which is carried on after the time limit is passed, is performed at a loss. Under such conditions, the contractor has little time to devote to the construction of temporary guards, which would have to be torn down within a short period. The safety of the workmen is thus menaced by dangerous conditions which should not exist. In scarcely any other line of work is there greater need of suitable safeguards, and caution and watchfulness among all concerned.

Excavations. — Excavations for buildings and other structures should be surrounded by a substantial railed fence to bar the public from the premises. Watchmen should be stationed at entrances to prevent any unauthorized person from gaining admittance. Conspicuous "NO ADMITTANCE" signs should be placed at all entrances.

Excavations in dangerous ground, which is likely to slide or cave, should be substantially shored. Braces should be placed every few feet in bad ground. All trenches should be so protected with barriers that no one can accidentally fall into them. At night, all trenches should be guarded with red lanterns, placed sufficiently near together to offer adequate protection.

The walls of adjacent buildings should be shored when there is the slightest danger of their settling or weakening.

It is often necessary to shore an adjacent building when a given building is being razed. In any case, the shoring should, if necessary, take the weight of the wall as well as brace it. Strong, powerful jacks should be used, with properly blocked steel rails or I beams as a support. Braces should be so placed as to evenly distribute the pressure.

All temporary openings for manways and hoistways in the street or sidewalk should be guarded with a substantial railing and toeboard.

Where derricks or steam shovels are used, the need for caution is very great. The hoistman should not be signaled to move or hoist a load until all workmen stand aside in a safe position. Loads should not be directly carried over the men. Workmen should be warned to keep from under suspended loads at all times. No one should be allowed to ride upon a boom or a load.

Special care should be given to the excavation of sand and gravel pits. Men are sometimes buried alive from slips and falls of gravel. The banks should be kept trimmed of all loose material. Workmen should not be allowed to shovel far enough into the bottom of a bank to form an overhang. A safe slope should be maintained at all times. Before bank trimmers start to bar down the top of the bank, the workmen below should be notified in time to place themselves in a safe position. Trees should be felled before the face of the bank has approached within 15 feet of the trunks. A greater distance should be maintained with large trees. If the bank approaches too near a standing tree, the ground is likely to slip, allowing the tree to fall on the men in the pit.

Where blasting is required in the work of excavation, the precautions which are outlined under the Chapter on Explosives should be observed.

Scaffolding. — Scantling posts should be placed plumb, and securely fastened to prevent spreading. Ledger boards should preferably be fastened to scantling posts by means of clamps. This type of fastening is much safer than one

made with nails. If nails are used, at least five should be driven for each fastening. Put-logs should be placed at frequent intervals to prevent undue bending stresses in the planking. At least five 2" planks should be used for each footway. They should be cleated underneath and so fastened that they cannot tip or slip. The scaffolding should be securely tied to the building by a sufficient number of strongly fastened tieboards. The footway should be guarded with a standard handrailing 3½ feet high, with a 12" toeboard at the bottom. This is very important. Where handrailings and toeboards are not provided, men and material are likely to fall off. Many accidents result from this cause.

Judgment should be used in selecting good stock, which is free from large knots, knotholes, cracks and other defects. Care should be taken to see that the wood has not been "killed in the drying." Wood, which has been "killed," is rotten and unsafe.

The scaffolding should not be overloaded with either men or material, nor should it be used for storage purposes. Teamsters should be warned against accidentally driving or backing their carts against a scaffold. This might cause the structure to collapse. Foremen carpenters should never allow anyone to start work on a scaffold until they have thoroughly inspected all parts, assuring themselves that it is absolutely safe.

Safety scaffolding, suspended from above, which is raised and lowered by winches, is the safest type. This is of great value in filling in and facing the walls of steel framed buildings. Fig. 89 shows a view of one of these scaffolds. It is built in overlapping sections which are hoisted together by means of the winches. These may be securely locked against slipping by means of pawls. Scaffolds should also be provided with a substantial cover.

In five years, in New York alone, 660 deaths were caused by falls from new buildings, while 177 deaths were caused by falls from the old wooden form of scaffolds

supported by horses and cantilevers. These old type stagings should not be used on buildings of any height.

In two years, 319 buildings were erected with these

FIG. 89
"Patent" safety scaffolding.
Courtesy Patent Scaffolding Company, New York.

patent scaffolds where more than 8,265 machines were employed, and not one man was injured from a cause which could be attributed to the scaffolding.

The continuous platform is supported at intervals of approximately 10 feet by a safety scaffolding machine,

composed of two drums around which steel cables are roved, and the necessary supporting members, including a put-log which serves to support the planks forming the platform. The upper ends of the cables are securely attached to horizontal steel I beams or outriggers, which are fastened by means of U shaped anchor bolts to the framework of the building. The outriggers support the continuous suspended platform, which is raised or lowered by operating the two levers on each machine, thus rotating the drums. The winding force is applied to each drum by the lever arm. A pawl is mounted thereon, which engages one of the ratchet wheels on the sides of the drum. The platform can be raised or lowered by one man. Moreover, the platform can be operated in sections, which is often important when temporarily short of material, or when the outline of the building is irregular.

Swing scaffolds should be constructed with bent iron holders at each end, upon which the planks rest, and which contain sockets in which a toeboard and guard rail may be placed. The planking should be secured to prevent slipping or tipping. Toeboards are important to prevent pails and other articles from falling off. The supporting ropes should always be inspected before use. The scaffold should be equipped with two winches, one at each end. These machines should be of an approved type, so designed that there will be no danger of the rope accidentally unwinding.

Sidewalks. — Covered passageways should be built over sidewalks for the use of the public. They should be constructed of large posts and caps, with a cover consisting of two layers of 2″ planks. Where such tunnels are not used, the sidewalks should be completely railed off.

Footways and Runways. — Footways and runways should preferably be constructed with not less than five 12″ planks, at least 2″ thick. There should be an uneven number of planks where wheelbarrows are used, so that the wheel of the barrow may run on the middle plank

instead of over a crack between two planks. If the wheel is run over a crack between planks, it is likely to become caught, thus dumping the load. Footways and runways should be guarded with a substantial railing and toeboard. Planks should be cleated underneath, and fastened to prevent slipping or tipping. Inclined footways should be provided with cross cleats to prevent workmen from slipping. No attempt should be made to wheel material in a barrow up or down a steep runway. Planks of footways should be nailed at the ends to prevent them from projecting slightly upward. If not securely nailed down at the ends, the projections will cause persons to stumble. Footways should be free from holes, splinters, protruding nails and unevenness.

Floors. — While a building is under construction, floors should be temporarily built of planks. A floor should be completely planked over before another story is erected. The planks should be secured to prevent them from slipping or tipping. They should be placed near together to prevent tools and other articles from falling through the cracks upon workmen below. All floor openings should be guarded with a substantial railing and toeboard. Door openings in the side walls and entrances to elevator shafts should be kept guarded with railings. Floors should be kept free from boards containing protruding nails and from other débris. In razing a building, it should be torn down one story at a time. The uppermost story should be completely torn down before any part of the story underneath is demolished.

Stairways. — During the course of construction of a building, stairways with safe temporary treads and hand rails should be provided. Stairway openings should be guarded with a handrailing and toeboard. Stairways should be used in preference to ladders wherever practicable. Stairways should be kept free from all loose material and obstructions.

Ladders. — Ladders, which are built on the job, should

be constructed of rungs at least $\frac{1}{2}''$ by $2\frac{1}{2}''$, inset flush with the uprights. Stringers should be at least $2'' \times 4''$. The rungs should be secured by at least 3 nails at each end.

Ladders should be inclined at an angle of about 15 degrees from the vertical. They should be securely fastened at the top by means of converging cleats which are nailed to the planking. They should never be fastened by toe-nailing alone. They should be braced at the bottom to prevent slipping.

Construction ladders are usually subjected to a great amount of wear. Broken and cracked rungs should be immediately repaired. In damp places, the nails rust quickly and the wood wears in a short time. Under these conditions a ladder will soon deteriorate. Therefore, it is necessary to make frequent inspections of all ladders.

Roofs. — Before shingling, horizontal cleats, spaced at convenient intervals, should be nailed to the roof. These will afford a means of support for the carpenter. Safety belts and lifelines should be provided for men when working on steep roofs. Workmen should be forbidden to throw material from roofs, except into a space on the ground which has been railed off for this purpose. No material, which might be blown down, should be left on roofs.

Protruding Nails. — These are a constant menace in construction work. Foremen should make a special effort to prevent workmen from leaving boards about which contain protruding nails. Many cases of blood-poisoning, and some of lockjaw, result from workmen stepping on protruding nails. The nails should be clinched over, or entirely removed. The ends of the nails may be easily turned over with the claw of a hammer or with pliers, and then hammered into the wood.

When the heads of barrels, kegs, or covers of boxes are taken off, the nails which held the heads should be removed, otherwise workmen may lacerate their hands or arms in removing material.

It is just as important to take these precautions about

a factory as it is on construction work. Any scratch or cut, no matter how slight or insignificant, should be immediately treated with antiseptic to prevent blood-poisoning. Infection is just as likely to result from minute scratches or punctures, as from cuts from which a considerable amount of blood flows. The minor scratches, cuts, and bruises are often the dangerous ones.

Floors, aisles, footways, drives, and footpaths about the buildings should be kept clear of débris of all kinds. Where there is a large quantity of loose boards with protruding nails, they should be carefully piled with nails facing downward. Men should wear thick leather gloves in handling and piling boards or other rough or sharp material. Heavily soled shoes are especially important in preventing injuries from protruding nails. Protruding nails should also be removed from posts, beams, and walls.

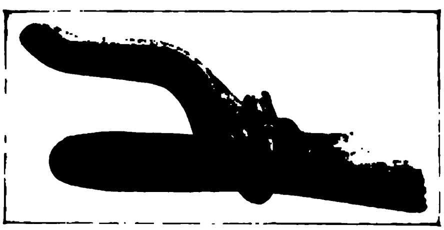


Fig. 90
Knuckle guard for handles of wheelbarrow.
Courtesy National Founders' Association.

Wheelbarrows. — The handles of wheelbarrows should be equipped with suitable guards to prevent the hands of workmen being bruised or crushed in case they are jammed against any obstruction. (Fig. 90.)

Waste Disposal. — Waste or débris should never be carelessly thrown to the ground. Properly constructed chutes should be built. These should lead to a bin about 10 feet above the ground, which is provided with a gate. The débris may then be dumped or shoveled into a cart and hauled away. If the waste is thrown directly to the ground, a space should be substantially fenced off for its reception. Warning signs should be placed on the fence to keep workmen away.

Machinery. — Special attention should be given to guarding belts and pulleys, gears, and chains and sprockets

on machinery which is used for construction purposes. Rip saws, cut-off saws, and jointers should be equipped with guards at the point of operation. Glasses should be provided for the operators of emery wheels.

Steel Workers. — The erection of structural steel is one of the most hazardous classes of work, hence the pressing need of selecting fit men and of insisting that the work be done in the safest manner possible. A steel worker should be fearless, sober, alert, agile, keen, and in perfect physical and mental condition to cope with the dangers which constantly surround him. Steel workers should be between the ages of 23 and 40. They should use safety belts when guiding girders and when riveting. Safety belts should receive a daily examination.

Workmen should not be allowed to ride on derrick booms nor upon loads. They should be cautioned against taking any unnecessary risks. The risks are sufficiently great without needlessly increasing them.

Hot rivets should not be tossed carelessly to riveters. This is a dangerous practice unless the distance is short and a large pail is used to catch the rivets. Rivets should never be thrown upward to men above on the steel framework. They should be drawn up in a pail with a hand line. All rivets should be hammer tested when set.

Safety clamps should be used in handling steel beams, girders, and other parts. Hookmen should see that the beams are properly hooked and balanced. The balance should be tested before starting to hoist. Hoistmen should have a direct view of beams and columns when placing them. Great care is necessary in placing beams on their seats or lugs in order not to injure the steel workers who are stationed to guide and fasten them.

Safety should not be sacrificed for time. Foremen can do much toward preventing careless and unsafe practices. Workmen should not be allowed to fool or indulge in any demonstrative acrobatic feats or disputes when on duty.

RULES FOR CONSTRUCTION OPERATIONS

1. Before placing any workmen upon a scaffolding, the foreman carpenter should thoroughly inspect all parts, to see that sufficient nails are holding the ledger boards, and that there are no defects in any part of the structure. Clamps are preferable to nails for use in fastening ledger boards to scantling posts.

2. Before going upon a scaffold of any description, every employee should see for himself that the scaffold and supports are properly and safely constructed. Sufficient time should be allowed to each employee to make this examination. Employees should be forbidden to work upon any scaffold, until they have satisfied themselves, by such personal examination, that the scaffold is safe.

3. Carpenters should use judgment in selecting good, clear stock, free from large knots, holes, cracks or other defects. Many accidents are caused by defective material breaking or failing, allowing workmen to fall.

4. Scantling posts should be set plumb, and secured with a sufficient number of ledger boards.

5. Scaffolding should be securely fastened to the building by a sufficient number of tieboards or ropes.

6. There should be a sufficient number of put-logs (same applies to scantling posts), spaced near enough together to eliminate any dangerous bending stresses in the planking.

7. Footways and runways should be constructed of at least five 2″ × 8″ or 2″ × 10″ planks — never less. The planks should be cleated underneath at the ends and middle, and securely fastened to prevent slipping.

8. All footways should be guarded by a substantial railing, 3½ feet high, with a toeboard at least 10 inches high.

9. Never overload a scaffold.

10. Drivers should be cautioned, by the superintendent or foreman, not to hit any part of scaffolds, ladders, etc., with their carts or trucks.

11. Swing stagings should be equipped with a guard rail and toeboard, and a patent hoisting machine should be used. Ladders should not be used as a support for swing stagings. The planking for the scaffolds should be secured, and should cover the entire space between the supporting ropes. Examine all supporting ropes before using the swing staging. In large operations, or wherever work is done overhead, a patent scaffolding should be used, which should be provided with a substantial cover, to protect the men from falling material.

12. No material of any kind should be piled on scaffolds for storage purposes.

13. Never place men at work under masons, if it can be avoided. If it is necessary to do so, provide a covering for the men working below.

14. All construction ladders, if made on the job, should have all the rungs (at least ½″ × 2″ in size) inserted into sockets, and fastened by three nails at each end. Ladders should be securely fastened to the scaffolding by means of converging cleats, nailed to the planking of the footway. They should never be fastened by toe-nailing alone. Ladders should be secured at the bottom to prevent slipping.

15. If it is impracticable to fasten a ladder, when on a small repair job, get someone to hold it.

16. See that all open spaces in floors are either guarded, or covered with planking. The planks should be placed so near together that no tools or material can fall through the cracks, and so that the planks cannot tip up on end.

17. See that all permanent floor openings, stair openings, door openings, and entrances to elevator shafts, are kept properly protected, at all times, with substantial railings.

18. Allow no boards, containing protruding nails, to remain about the floors, or footways in the yard. See that the nails are either removed or clinched over, or the boards placed in separate piles, with the nails extending downward.

19. Do not allow débris of any kind to collect in working places, or in the yard. See that it is kept in separate piles, and properly disposed of.

20. Passageways should be constructed over sidewalks, in order that the public may pass by in safety. The passageway should be built of heavy timber, and completely covered with 2-inch planks.

21. All runways should be constructed with an uneven number of planks, such as three or five, so that the wheel of the barrow may be run on the board in the center; otherwise, it is likely to catch between the boards, and wedge them apart, dumping the load.

22. Never run with a wheelbarrow on a runway.

23. See that wheelbarrows are provided with guards, placed on the handles, to prevent workmen from crushing or bruising their hands, should the handles hit obstructions.

24. Never drag a wheelbarrow behind you, when on a staging or runway.

25. In wrecking a building, the floors and walls of the uppermost story should be razed completely, before any part of the lower story is taken down.

26. All temporary stairways should be provided with safe temporary treads of sufficient width; also, handrailings, and a railing on the sides of the stair openings.

27. When excavation is being carried on at any place, it should be protected by barriers, and at night by lights.

28. All excavations, that are likely to cave in, should be shored up.

29. Banks, in sand or gravel pits, should be kept constantly barred down, and trimmed of all loose material. Bank trimmers should notify men working below them.

30. Never allow any material to be thrown to the ground, unless a space has been completely railed off, with warning signs posted on the fence. It is safer to throw the material down properly constructed chutes to a bin below, which is provided with a gate.

31. Care should be used in making safe fastenings for all loads to be hoisted, and in adapting the proper slings to the material at hand. Care should also be taken to see that there is no chance of the load tipping or slipping.

32. Hooks, with the opening between the point and shank barred, should be used when hoisting material in tubs, or other receptacles, or when there is danger of the bail or sling unhooking, on account of the load catching on obstructions.

33. Be sure that the signals, used when hoisting material, are thoroughly understood.

34. Operators of hand operated hoists should have the load under control at all times, and should be careful not to lower too fast.

35. No load, even though it be light, should be allowed to descend so rapidly as to make the handle of the winch revolve at high speed.

36. Never hoist concrete, bricks or other material in wheelbarrows, through the air.

37. When chipping or lumping, always wear goggles; and place a portable screen to prevent chips from flying into the eyes of workmen, or other persons, who may be working near, or passing by.

CHAPTER XIX

STEAM AND ELECTRIC RAILROADS

THE annual loss of life and limb from railroad accidents is appalling. It is gratifying to know, however, that a very large percentage of these accidents are preventable; that many companies are actively engaged in waging an unrelenting campaign to eliminate accidents; and that their efforts are meeting with unusual success.

Education best insures safety and efficiency. Training the employee is the key to the problem. It is the human element which has the most important bearing upon the case. Never can the railroads meet with success in reducing accidents until the employee is educated and versed in safety; nor until he is trained to avoid unsafe practices and to abandon the habit of taking chances.

Employees of railroads are so accustomed to the dangers which surround them, that they constantly indulge in unsafe practices. The employee must be educated to think of safety and to practice it, not alone for personal security, but for the welfare of his fellow employees and for others whose safety depends upon his judgment and caution. Discipline is an important element in the correction of unsafe practices. Employees who repeatedly indulge in dangerous practices should be summarily dismissed from service. This will serve as an impressive warning to others. Safety, and safe men, above all, should be demanded by those in authority.

Railroads may continue to eliminate grade crossings, buy steel cars, guard machinery, and install automatic safety contrivances, but they can never eliminate accidents by merely improving physical conditions. This does not

mean that the improvement of physical conditions should slacken; on the contrary, activity in this direction should increase. Of still greater importance, however, is the creation of a railroad organization, thoroughly trained and drilled in safety.

Efficient safety committees should be organized. Through this medium of co-operation, results may be

FIG. 91

Dangerous practice of attempting to mount foot-board of approaching engine while standing between the rails.

Courtesy Norfolk & Western Railway Company.

obtained by education, supervision and corrective discipline. Employees should be required to familiarize themselves with the rules of the company, with the idea that they will be called upon to pass an examination at any time. Examinations should frequently be held. These will tend to insure active remembrance and efficient execution. Employees should be intelligently supervised. Lives should not be weighed against dollars and time, nor jeopardized by reckless and careless practices.

Efficiency tests should be made by superintendents, trainmasters, and road foremen of engines, of all employees whose work is in any way connected with the active operation of trains. These tests will train the men to closely observe the rules. The tests should be conducted in different ways, embracing all the primary hazards incident to the movement of trains.

FIG. 92
Result of attempting to mount foot-board of approaching engine while standing between the rails.
Courtesy Norfolk & Western Railway Company.

During the year 1913, more than 15,000 danger signal efficiency tests were made by the Southern Pacific System. The average percentage of efficiency was 99.56%. At different points of the system, and at various times during the year, switch lights on straight tracks were reversed; automatic blocks set at "stop"; fusees lit and thrown near the track; markers and indicators changed; flagmen tested on proper train protection involving promptitude, distance,

and use of fusees and torpedoes; and various other tests made, all without the previous knowledge on the part of the train and engine crews tested. Out of 2,286 tests, which were made in one month, there was not a single instance in which the employees failed to observe and comply with the rules and instructions, the average efficiency being 100%.

Fig. 93
It is unnecessary to go between cars to couple or uncouple them. The handle, shown more completely in Fig. 100, should be used.

Courtesy Pennsylvania Railroad Company.

In order to determine the primary cause of grade crossing accidents, and the remedy therefor, the Southern Pacific System inaugurated observation tests at various times and places of automobile drivers, teamsters, and pedestrians. In all, 25,296 of these observation tests were made. It was discovered that 58% of all three classes neither stopped nor looked in either direction for an approaching train. In the case of automobile drivers, 69% neglected these precautions. With a view toward remedying these conditions, this information was given wide publicity through the press. The matter was also brought to the attention of automobile clubs. Enginemen and trainmen are constantly impressed with the necessity of keeping a sharp lookout and of sounding advance signals when approaching grade crossings. Their attention is also directed to the importance of compliance with the rules in reference to switching and other movements.

Lodges of trainmen and enginemen should be regularly visited by an assistant to the general manager for the purpose of delivering addresses dealing with all the hazards connected with the operation of railroads. An exhibit car containing models, charts, photographs of unsafe practices and dangerous places, and other safety devices, should be maintained in charge of a board of examiners. This car should continually travel over all the lines of the company. It should be used for the education of employees, particularly those engaged in train and engine service. Examinations should supplement this educational work. Moving pictures and stereopticon views of dangerous practices should be used to interest employees. These methods will establish a spirit of co-operation between employees and officials, resulting in a unification of effort in the promotion of safety.

Tracks, bridges, rolling stock, structures, and machinery should be maintained at a high standard. Grade crossings should be eliminated, wooden coaches should be replaced with steel cars, automatic block signals and interlocking systems should be installed, double tracks should be built, curves should be reduced, heavier rails should be used, and various other activities should be continued to make safe railroad systems.

Safety on Locomotives. — Engineers usually are, and always should be, interested in safety. Those that are not have no place as masters of locomotives. None but a temperate, intelligent and reliable man should be given charge of a locomotive.

The engineer should keep a perfect lookout from the cab. On all curves leading to the left, it is necessary for the fireman to keep a lookout from his side of the cab. The fireman should be made to realize his responsibility in the safe movement of the train. Firing should be done on straight stretches of track, not on curves. When rounding curves, the attention of the fireman should be devoted to keeping a sharp lookout.

The engineer and fireman should refrain from arguments or conversation when on duty. This rule should be persistently followed until, finally, silence will become a habit. The engineer should train his fireman to refrain from talking to the flagman whom he may pick up on the engine. The fireman should realize that he is the engineer of tomorrow, and that it will be to his credit, as well as to that of the company, for him to be thoughtful, watchful, and efficient. He should be agreeable, alert, and willing to render all necessary assistance. The engineer should set a high standard of efficiency and watchfulness for the fireman.

The engineer should take pains to make smooth, easy stops, free from shock, using the same care in starting to avoid injury to passengers. He should not attempt to make up lost time by driving quickly in and out of a station regardless of all rules.

The matter of distinct whistling, when approaching highway crossings, is important. Engineers should also be careful to give a sufficient warning signal to section men and others, who seemingly do not notice the train, and are likely to be hit, without waiting until it is too late.

In approaching all hazardous places and interlocking plants, where the vision is in any way obstructed, the brakes should be applied in ample time to insure safe stopping of the engine, in case the track should not be clear. This same practice should be carried out when approaching stations where passengers are likely to get beyond the clearing point of the station platforms, and also at points where two trains have a meeting at nearly the same time.

The coal on the tender should be so placed that it cannot roll off, causing injury to persons near the track.

After engines start to make steam, gauge cocks should be tried to test water gauges, in order to be sure that the water level in the gauge glass is not deceptive. The low water alarm should also be tested.

In oil burning locomotives, should the fire go out, it

should be relighted with a torch as in the first operation. The fireman should stand well away from in front of the fire door, protecting his head and face from a possible explosion. Employees should never carry open lights around manholes on oil tanks of locomotive tenders. Fuel oil should not be allowed to overflow on top of locomotive tenders when filling them. Special attention should be given to the drippings of oil burning engines, especially in the round house.

Firemen should remain in their proper position in cabs while locomotives are entering or approaching stations, and also at points where water, coal or oil is to be taken on. They should constantly ring the bell when the engine is stopping or starting, approaching crossings, and moving about the yard or near any persons. Firemen should not be allowed to leave the cab until the engine comes to a full stop.

When going through tunnels, where men are working, cylinder cocks should not be opened. They should be allowed to drain before starting out of the round house. They should then be closed until clear of the building. Care should be taken to see that they are not opened in the vicinity of employees.

Squirt hose should not be hung in the gangway of locomotives. It may be mistaken for a hand hold when boarding the engine.

When on the road, care should be taken in sanding engines to prevent any possibility of setting fire to dry grass.

Five minutes before the arrival of trains at points where cars or engines are to be cut in or out of passenger trains, the rear brakeman should open the steam heat valve at the rear of the last car, allowing the steam and condensation to escape. Enginemen should close the steam heat line with the fountain valve. This drains the piping, avoiding the possibility of switchmen and carmen being scalded when coupling cars.

Hostlers should be held strictly responsible for the condition of all engines at the time they leave them in the round house or designated track. They should be left with the throttle tightly closed, the reverse lever in center position, the cylinder cocks open, blocks under the wheels, and dampers and fire door tightly closed. The firing valve, tank valve, and blower (oil engines) should be closed, unless the engine is left under steam in charge of an engine watchman.

When placing an engine or cars on any track, care should be taken to see that they are left in a position which allows sufficient clearance to any adjacent track or building.

RULES FOR LOCOMOTIVE ENGINEERS

1. Never, under any circumstances, disobey orders or signals.
2. Do not take any unnecessary risks; there are too many necessary ones.
3. Never talk to anyone while running an engine. Train your fireman to do likewise.
4. Remember that most accidents occur at or between switches, and that the majority of them occur at night.
5. Never use liquor, even when off duty.
6. Be alert at all times, especially when approaching signals, switches, stations, crossings, and when running through yards. Use extra care at night.
7. Train your fireman to be on the lookout, especially when taking a left hand curve. Be sure that he constantly rings the bell at all dangerous places, where persons are likely to be injured.
8. Never allow your mind to wander from your work.
9. Train yourself to constantly think of what you are doing.
10. Never go on duty unless you are physically and mentally qualified to do so.
11. Never become angry or worried. Your mind should be solely concentrated on your work.
12. Don't become grouchy with your fireman. Be pleasant and agreeable. Remember that you are a promoted fireman.
13. Never allow a third man in the cab.
14. Never start your engine unless the fireman is ringing the bell.

Hot Boxes. — The journals on all cars should receive constant and thorough inspection, to insure that they are sufficiently lubricated to prevent the possibility of a hot-box. Should a hot-box occur unnoticed, the bearing would likely burn out and the support give way, possibly causing

a wreck. On a long freight train, as one of 75 cars, a hot-box is likely to remain unnoticed until the bearing burns out, whereas, on a shorter train, as one of 40 cars, it is often detected in time. Constant vigilance is necessary to prevent hot-boxes.

Automatic Block Signals. — Signals, if practicable, should be placed either over (on a signal bridge), or upon the right of, and adjoining the track to which they refer. Semaphore arms, which govern, should be placed to the right of the signal mast, as seen from an approaching train. A mast may have a cross piece on which two uprights (no more) may be mounted on which to place signals. One upright may be a stub, to indicate that the corresponding track has no governing signals. Not more than one track should intervene between a bracket signal mast and the track for which its left upright carries a signal arm. There should be a definite place for the flags and hand lanterns when used for signals; they should be fixed by a flag socket and a lantern hook on the side of the signal station toward the direction of an approaching train, and convenient for the operator to reach from one of the windows.

High speed movements should be governed by high signals and low speed movements by low signals. Not more than two high speed signals should be displayed on one mast; the top arm to govern unrestricted speed, and the lower arm to govern all other high speeds. All low speed movements should be governed by one arm low signals of dwarf construction. A distance signal should be provided for each high speed route. "Red" should be the "color" stop indication, and the "horizontal" position of the arm should be the "position" stop indication for all home signals. A mark of distinction should be made between automatic block signals and all other home signals, whether interlocking, train-order or manually operated block signals. Home block signals should be provided at all interlocking plants used as block stations.

All mechanically operated high speed signals should be pipe connected. Low speed signals may be wire connected. One distance signal only should be provided for a high speed route, and when "clear," it should mean that all high speed home signals along that route through the interlocking plant, including the home block signal, are "clear." Every movement within the limits of an interlocking plant should be governed by an interlocking signal. In view of the recent trend of development of the art, the following recommendations are made as desirable improvements on present practice: (*a*) that a red light shall be the night indication for "stop," a yellow light for "caution," and green for "clear"; (*b*) that day indications shall be given by semaphore signals in the upper right hand quadrant; (*c*) that the semaphore arm horizontal shall indicate "stop," inclined upward 45 degrees "caution," and inclined upward 90 degrees, or vertical, "proceed."

Crossings. — Grade crossings should be abolished as fast as practicable, as these are the source of many fatal train accidents. All grade crossings should be equipped with conspicuous "RAILROAD CROSSING" signs. Gates should be installed at crossings where there is considerable traffic. Flagmen should be placed on duty to operate them. All grade crossings should be protected with automatic bell signals.

Tracks should be completely fenced off on each side all along the right-of-way.

Tracks along the streets in a town or city should be abolished. They are especially dangerous on account of small children who are carelessly allowed to play in the streets. In this case, the speed of trains should be limited to 10 miles an hour.

Where factory employees pass to and fro from buildings on either side of the tracks, or where they cross tracks in large numbers before and after working hours, bridges or viaducts should be provided. (Fig. 94.) Direct entrances upon a track should be guarded.

City stations, other than terminals, are now constructed with a subway underneath the tracks, which runs from the station to side stairways leading up to the platform of each track. This does away with the necessity of passengers crossing the tracks on their way to and from trains.

Flagmen. — Flagmen of good eyesight and hearing should be selected. They should make it a point to close

.Fig. 94
Viaduct for safety of employees.
Courtesy Illinois Steel Company.

the gates in sufficient time before the approach of any train, to insure a wide margin of safety. They should warn pedestrians against walking around or under the gates after being closed. They should be alert and watchful at all times.

Switches and Frogs. — Stub switches should never be used, especially on main lines. It is safer not to use them in a plant yard or siding. The gap in the rails is always sufficient to cause considerable jar to rolling stock. When operated as a trailing switch, a derailment is inevitable, if the switch is misplaced.

Split switches should be used. These leave one main rail unbroken. The point rails are tied together with tie-rods. They are held in place by a very stiff spring which will yield sufficiently to permit the wheels to remain on the rails if a train trails through with the switch misplaced. The rails of the frog are always made straight, therefore the lead rails between the switch point and the frog must be curved to a circular arc which is tangent to both the switch rail and the wing rail. All switches should be provided with a locking device. Switch stands should be so constructed that the ball will be thrown parallel to the rails.

Fig. 95

Folding car blocker for protecting tracks on an incline or at entrance to building. Blocker is shown locked in raised position. When not in use, it is thrown to the right to clear the rail.

Courtesy Commonwealth Steel Company.

Spring rail frogs, having one wing rail (the one connecting with the main rail) movable, and yet normally pressing against the frog point, should be used. There should be no gap to be passed over by the wheels running on the main track. Guard rails should be so placed that, when the wheels are running through the frog to the switch, the guard rail opposite the frog will force the opposite wheel to run in its proper line, thus causing the inside of the flange of the wheel running through the frog to press against the wing rail, forcing it back so as to leave a sufficient opening between the wing rail and the frog point for the wheel to pass through.

A switch, which permits the use of unbroken main rails, necessarily lifts a car to a vertical height somewhat greater than the depth of the wheel flange. As this must be ac-

complished within a distance of a very few feet, it is impossible to use such switches for high speed. These devices have not come into common use.

All switches, frogs, and guard rails should be filled with steel or wooden blocks to prevent anyone's feet being caught in the wedge. (Fig. 96.) This is important, as many accidents have resulted from a person being unable to release his foot before being run over.

Derails. — Suitable derails should be installed at the proper point on spur tracks or sidings with a grade. The purpose of a derail is to prevent a freight car from rolling from the spur track or siding upon the main track, in case the brakes do not hold.

Fig. 96
Steel foot-block for protecting guard rails and frogs.
Courtesy Commonwealth Steel Company.

Buffers. — Buffers should be placed at the ends of all spur tracks, especially where the track terminates on trestles, banks, in front of buildings, or down grade inclines, and in stations, to prevent the train backing off the track, causing damage or injury to persons or property. The buffers should be substantially constructed, and well braced or stayed. Reinforced concrete buffers are most satisfactory.

Clearance. — There should be sufficient clearance between spur tracks or sidings and adjacent buildings or structures, to prevent workmen being caught and crushed at such places by moving cars. Danger signs and guard rails should be placed where the clearance is small. The space between the track and the buildings should be covered over with boards or metal plates, inclined at an angle of 45 degrees, to prevent anyone walking or standing between the track and the building.

Overhead structures should be at least 7 feet above

the highest freight cars. If the clearance is less, warning ropes, spaced not greater than six inches apart, should be suspended over the track one or two hundred feet on either side of the overhead obstruction.

Cattle Guards. — A cattle guard consists of a winged fence on each side of the track, extending from the right-of-way fences to the end of the ties; also, aprons consisting of short sections of fence set parallel to the track at the track end of the winged fences; also, a pit or rough surface on which cattle will refuse to walk, extending for a short distance, about 8 feet, the entire width of the track between the outer ends of the ties.

Surface guards are preferable to pits, on account of the disastrous consequences which might be caused by a derailment at the guard, due to the failure of the pit structure. A surface guard should cover the ties with some one of a variety of wooden or metal slats or tiles, shaped like an inverted V. It should be so designed that it will not catch dragging brake chains or other rigging, and should not endanger employees who must walk over it. Barbed wire should not be used. The guard should be so built that it cannot catch and hold cattle which attempt to cross it.

Transfer Pits. — These should be guarded with a substantial iron pipe railing to prevent employees from getting into the pit and becoming crushed by the tables.

Trestles. — All trestles should be equipped with handrails and toeboards, to afford a safe footway, when necessary to use the trestle as such. The footway should always be close boarded.

Open spaces between the ties should be completely covered where the trestle or bridge runs over a driveway, areaway, passageway, or any other place where workmen are exposed to falling material from the trestle, such as coal and ore.

Factory Yards. — These should be enclosed with open fencing. Closed fencing should not be used on sides where

there are entrances or gates, as the vision would be obstructed. Locked gates should be placed over all tracks entering the yard, and also at driveway entrances. These should also be of open construction, preferably of the sliding type. Fences and gates should not be built solid, as it is then impossible to see approaching cars, engines or vehicles.

A conductor or brakeman should be placed at the end

FIG. 97
Guard gate for track crossing in factory yard.
Courtesy Commonwealth Steel Company.

of every freight train when switching is in progress, to make sure that no one will be injured.

Substantial railings should be placed in front of door openings directly in front of a track, to prevent employees from carelessly rushing or walking upon the track when coming out of the building. Railings should also be placed at the corners of buildings which are close to the tracks.

Loading and Unloading Material. — Sand, rock, gravel, ore, lumber or any other material should never be placed within 6 feet of the nearest rail, in order that there may be a safe clearance between the cars and the material.

Where this is impossible, warning signs should be placed at each end of the pile to prevent persons passing between the pile and the track.

Hand trucks and gang planks, for transferring material on sidings to and from a building platform, should be kept in good condition. Special care should be taken in loading or unloading cars with dangerous explosives, inflammable materials, and chemicals. This work should be done under the supervision of a competent foreman. In loading, material should be carefully stowed. All packages, boxes, carboys and cans should be secured against possible movement, displacement or breakage during transit.

FIG. 98
Unsafe practice of riding on brake rigging while clinging to a hand hold.
Courtesy Chicago & Northwestern Railroad Co.

Agents and receiving clerks should carefully inspect all consignments of inflammable liquids, to see that the containers are tightly closed, the bungs screwed in tightly, and that there is no evidence of leakage. Shippers should be impressed with the necessity of screwing the bungs in with a wrench, so they cannot be loosened with ordinary handling.

Oil Tanks. — The utmost vigilance should be exercised in handling and storing fuel oil. Leaks that develop in pipe lines or tanks should be promptly repaired.

In cleaning out an oil tank, it should first be drained of all oil. The manhole cover should be removed, and sufficient time allowed for the tank to thoroughly drain. If the oil is thick, or repairs are being made in cold weather,

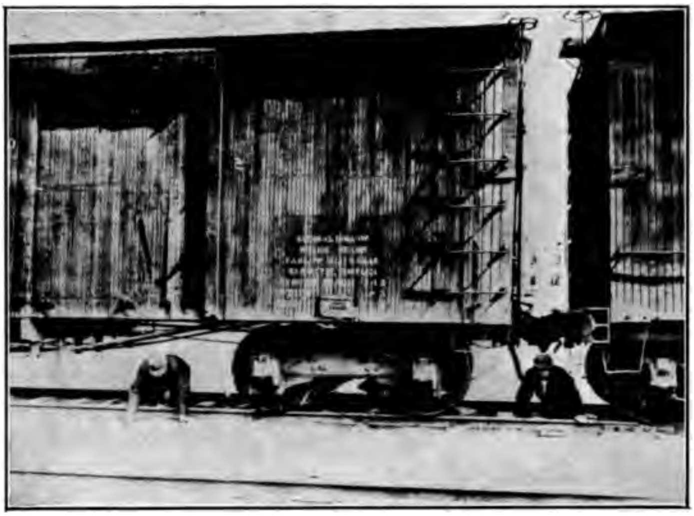


Fig. 99
Many men are killed every year by attempting to crawl underneath cars.
Courtesy Chicago & Northwestern Railroad Co.

steam should be admitted to heat the tank and oil to facilitate draining. While the tank is being steamed, the manhole may be covered with canvas or sacking to confine the steam. There will thus be no danger of sufficient pressure being created to cause any damage.

After the tank has been thoroughly drained of oil, the inside should be wiped with waste soaked in kerosene oil. Benzine, gasoline or turpentine should not be used. There is less danger of gas formation with kerosene. While

cleaning the inside of the tank, the manhole should be uncovered, and the outlets at the bottom of the tank opened, affording as good ventilation as possible.

In case the tanks have been used for gasolene, naphtha

Fig. 100
Dangerous practice of sitting on hand wheel. A severe jolt might cause a serious injury or even death.
Courtesy Pennsylvania Railroad Company.

or other light oils, the manhole cover should be removed and the tank steamed for a sufficient time to remove all the gas.

There should always be a man with a rope outside the manhole, watching, so that if a man is overcome with gas, he can be quickly removed.

Under no consideration should an open light or fire be allowed inside or about oil tanks. When making repairs, hot rivets should not be driven until the tank is thoroughly cleaned and ventilated.

FIG. 101
Climbing between cars is often a short cut to death.
Courtesy Chicago & Northwestern Railroad Co.

RAILROAD AND YARD RULES

1. Before crossing any railroad track, always stop, look in both directions, and listen. Make sure that you can cross in safety. Then go ahead.
2. Do not cross any track, either in a yard or crossing, or on a street, directly behind or in front of an engine, railroad car or trolley car. Something may be approaching on an adjacent track that you cannot see. Wait until you have a good view, and then look both ways before crossing.
3. Refrain from trespassing on tracks. Deliberately walking the tracks is to put your life in danger. The majority of persons killed on railroads each year are trespassers, who are killed through their own negligence. Never walk the tracks to and from your work. When you are with one or more persons, do not depend upon them for your own safety, but look out for yourself.
4. Never attempt to board or alight from moving cars. In alighting, see that you are stepping upon a safe footing.
5. Never take refuge at the sides or ends of, or underneath cars, either from rain, snow or sun, or for any other reason.

6. Never get off any car backward. When alighting, face ahead, and hold on to the hand rail with one hand.

7. Never climb between, or crawl under cars.

8. Never stand too close to the track, when cars are approaching or passing.

9. Familiarize yourself with the places about the plant, where there is no clearance for a man on the side of a car. Take care that you are not caught and crushed at such places.

10. None, but those whose duties require it, should be allowed to ride on engines or cars.

11. Never place tools, or material of any kind, where they will be struck by cars. Clean up all rubbish near the track, and never leave any material for others to stumble over.

12. All frogs, switches and guard rails should be safely blocked.

13. All switch bridles should be so close to, or distant from ties, as to prevent a foot becoming caught between the bridle and tie.

14. When new switch stands are installed, they should be so constructed that the ball will be thrown parallel with the rails.

15. All dangerous railway crossings should be provided with automatic bells, or other suitable warning signals.

16. There should be a clearance of at least 4 feet from the rail for all buildings, or other structures, on a straight railway track, and at least 4½ feet on curved tracks.

17. In unloading cars, material should be piled at least 6 feet from the rails.

18. Switchmen should protect crossings, where there is danger of workmen crossing in front of, or between, moving cars.

19. All switches should be left lined up as found.

20. Trains should be brought to a full stop, before cutting cars loose from an engine.

21. Flying switches should be positively forbidden, except where specifically approved because of necessity. Special permission should be obtained from the yardmaster.

22. Switchmen should be forbidden to stand between rails, and attempt to board a locomotive or car, which is approaching.

23. Switchmen should be positively prohibited from going between cars to pull pins, while the cars are in motion.

24. Never kick a drawbar to make a coupling. Switchmen should be forbidden to go between cars, on the inside of a curve, to pull pins or make couplings.

25. Use the pin to guide the link in the drawhead. Do not use your hand, and keep your fingers out of danger. Never use your foot to open drawheads.

26. Head foremen, yardmasters, and switchmen should be prohibited from running or moving engines.

27. In moving cars in any of the buildings, or about the yards, the responsibility should lie with the switchmen, to know that no one is in a position to be injured. At least one switchman should be stationed at the head of each car or train movement, and in the event of coupling to, or moving, a car, which is in a building, one switchman should be at the far end of the car, before the car is moved, or the coupling made.

28. In loading material on cars, care should be taken that no portion will project over the sides, or be likely to fall off in transit. See that the weight of the load is properly distributed over the car, and that large pieces are braced to prevent shifting.

29. No car should be handled, which is overloaded, or which is improperly loaded, endangering life or property.

30. When dumping cars, exercise great care to prevent the dumping lever flying and striking you. Do not block up side dump gondola car doors.

31. Do not walk alongside of cars, when material is being thrown from the car.

32. Do not set cars, locomotive cranes, steam shovels or engines, on inclined tracks, unless absolutely necessary. If this becomes necessary, they should be securely blocked or chained, and brakes applied.

33. Cars, which cannot be shoved into clear, should be protected by a red flag by day, and a red lantern by night.

34. A signal, imperfectly displayed at any point, or the absence of a signal at a place where a signal is usually shown, should be regarded as a "STOP SIGNAL."

35. No attempt should be made to descend inclines with more cars than the engineer believes can be safely handled, depending upon the condition of the rails, whether wet or dry.

36. When moving cars on tracks, where the vision is obstructed, the crew should ascertain if the track is clear before proceeding.

37. After unloading cars, see that all loose material is removed from the trestle.

38. Conductors and switchmen should be held personally responsible for accidents to men that may be working around tracks or cars.

39. Switchmen should see that points fit close to the rail, and in the event of any defect, the track foreman should be immediately notified, and repairs made, before the switch is used.

40. Conductors and switchmen should report to the superintendent all cases of defective couplings, brakes, steps, hand-holds and other parts of mechanical appliances.

41. No material should be piled on the end of tracks inside the bumping posts, or at the end of any stub tracks, where there are no bumping posts.

42. Guy lines should not be fastened to railroad tracks, until the switches are spiked on such tracks, and the tracks abandoned. All guy lines, fastened near tracks, should be carefully examined to see that there is at least 4½ feet clearance, and at least 22 feet top clearance, for passing cars.

43. When coupling or shoving, do not stand on footboard between engine and car.

44. Never go between moving cars under any circumstances. If necessary to go between cars, they should first be stopped. Be sure that your position is known, and that you are protected from movement of the cars.

45. Never go under cars for repairs, without placing warning flags at each end of the car.

46. Never ride on brake rigging, journal-boxes, truss-rods or other unsafe footings.

47. Never sit on brake wheel, side wall, or end of open box cars.

48. Never ride on the side of a car, hanging to a hand-hold, with your feet on the journal-box, truck-frame or foot-hold.

49. See that gang planks are in good condition, and secured, so they will not slip in trucking over them.

50. Never move cars at night without the proper lights.

51. Never allow cars to roll to a position, in "spotting them," without a brakeman.

52. Workmen should wear life belts and ropes, when unloading hopper-bottom cars.

53. When riding on top of freight cars, watch out for obstructions.

54. Never stand within the swing of tools of other workmen.

55. Workmen should be forbidden to ride upon any material hoist, derrick, steam shovel, locomotive crane, cars, or other moving bodies, unless their duties require it. They should also be forbidden to slide down any ropes.

56. When necessary to go under a steam engine, it must first be hooked up on center, cylinder cocks must be opened, brakes set, blocks placed under one or more of the drivers, and provision made to prevent any other car or engine moving against it.

57. Do not leave cars on sidings, in yards, or on the road, so that they will just clear. Leave them well in to clear, so that a man on the side of a car or engine, or an engineman with his head out of the window, will pass safely.

58. Before shoving cars that should be coupled together, slack must be taken.

59. Test hand brakes before depending upon them.

60. When using a stake or push pole to shove cars, stand on the side of the stake opposite the direction in which the car is to be moved, so that the stake moves from you instead of toward you. Do not try to shove too many cars with a stake, or use stake where tracks are too far apart.

61. When necessary to move cars that are unevenly loaded, use care to avoid overturning them. See that no one is on or about them.

62. Do not stand or place any part of body between lading and end of cars loaded with lumber or other freight which is likely to shift.

63. Do not ride on the top or side of an exceptionally high or large car when possible to ride on an ordinary size car. Face the direction the car is moving unless duties require otherwise. On Electric Division employees must not ride on top of any car, caboose or engine tender within three hundred feet of any bridge or other overhead structure having a clearance above the rail of less than 21 feet.

64. Do not lean beyond the line of cab or car without exercising care to avoid being struck.

65. When engines or cars are being pulled or lifted by rope, chain or cable, stand far enough away so that flying parts cannot strike you in case of breakage.

66. Do not sit or stand between the cab of an engine and apron or chute of coal dock while coaling an engine.

67. Tenders of engines must be so loaded that coal cannot roll off.

68. Do not let the squirt hose hang out of engine cab.

69. Do not start injector when likely to scald someone.

70. Trucks on station platforms must be properly secured or locked, with handles hooked up.

71. Never place a truck nearer than 6 feet from the nearest rail until an approaching train has stopped. Trucks should be pulled — not pushed.

72. When necessary to go back flagging, remember that the lives of many persons are dependent upon you. You are paid to " go back." Be sure you go far enough.

73. Do not use jacks with worn or broken teeth, loose fitting wrenches, nor chisels, punches or hammers with burred or "mushroom" heads, nor any tools with loose or cracked handles. When using a chisel, hold it with the hand well down from the top, so that if the hammer glances off it will not be so apt to inflict a serious injury.

74. Never fail to read aloud and compare train signals.

75. In operating hand cars, be sure you afford yourself all the protection possible. Go slow around curves on the down grade. Always stop the car and listen, or send a " lookout " ahead, before rounding curves.

76. Never operate hand cars close together.

77. Trackmen should stop shoveling at once, when signaled to do so by the foreman. Do not then try to remove an extra shovelful of dirt.

78. Persons should be forbidden to ride on platforms of cars.

79. Prevent persons from crowding on platforms at stations.

80. Never allow suitcases or bags to be left in the aisle of cars. Do not leave suitcases or bags on platforms of stations for someone to stumble over.

81. Never stand close to the track when a train is approaching or passing.

ELECTRIC LINES

Surface Cars. — The following are the details of the structure and equipment of the new center-entrance surface cars used by the Brooklyn Rapid Transit system. These cars mark a further advance toward safety and comfort than any other type of surface cars yet devised. They tend to greatly decrease boarding and alighting accidents. The wheel guards practically eliminate the possibility of anyone being run over:

All steel car body. Sides and structure of pressed and sheet steel. Mahogany sashes and steel doors. Roof and interior lining, sheet agasote, non-inflammable and non-conducting of electricity. Floor at entrance only 14 inches above rail. Standard H. B. wheel guards, with safety chains and stationary truck guards. Air brakes with emergency feature and special emergency control, allowing conductor to cut out motor and apply brakes independently of motorman.

Side doors operated by electro-pneumatic device and so adjusted with motorman's controller that the doors cannot be opened when the car is in motion, while the car, when stopped, cannot be started until the doors are closed.

Side doors protected on edges with rubber tubing so that, should the door be closed on a passenger, no injury would result.

Heaters controlled automatically by a thermostat.

Mechanical ventilation. Intake of air provided by screened openings in floor through heaters, exhaust through exhaust fan under bonnet.

Lighting by means of tungsten lamps; extremely wide windows and white enamel interior decoration give a maximum diffusion of light at all times.

Motors arranged for two running speeds allowing slow operation through congested streets and faster operation in outlying sections.

Push-button buzzer system for both passengers and conductor to signal motorman to stop the car. Starting signal entirely separate from the buzzer and consists of small electric lamps in front of motorman which are automatically lighted only when all doors are closed.

The new center-entrance car of the Brooklyn Rapid Transit System can be operated in all respects as safely and efficiently in trains as in single units.

Windows. — Windows of trolley cars should be guarded with grille-work or bars on the outside to prevent passengers leaning their heads, or thrusting their arms, out of the window with the consequent danger of being hit by an approaching car on the opposite track. Open electric cars should be equipped with railings to prevent passengers from falling or stepping out on the wrong side of the car.

Subway Cars. — The latest and safest type of subway car is that used by the New York Municipal Railway. This car has the following safety features:

Automatic speed control while the car is going down grades.

Steel construction throughout.

Plan of interior decoration developed in connection with scientific study of lighting system.

Sanitary floor corners, which render impossible the accumulation of dirt and reduce to a minimum the opportunities for germs to gather and breed.

SPECIAL SAFETY FEATURES

"Dead Man's" Emergency Control Handle. — A device incorporated in the controller operating handle that will automatically cause the power to be shut off and the brakes to be applied in case the motorman's hand is for any reason removed from handle when in operating position.

Conductor's Emergency Valve. — A device whereby, in case of emergency, the air brakes can instantly be applied to and power cut off from the entire train from any car in the train.

Empty and Load Brake Attachment. — A device that regulates the braking power in proportion to the passenger load, so that with increased load an increased braking pressure will be obtained.

Automatic Tail Light Change. — A device by which tail lights are automatically changed when reversing direction of train movement, or in case of motorman leaving train, when tail lights will show red on both ends of train.

Clasp Brakes. — Two brake shoes are used per wheel, thus producing a more uniform and smoother stop.

Electro-Pneumatic Brakes. — The latest development in Air Brakes, making possible a quicker and smoother stop than with the plain Air Brake without the electric feature.

Safety Spring Door Cushion. — Doors are equipped with a safety spring cushioning device, so that if door should accidentally strike a person, the shock would be reduced to a minimum.

Emergency Lighting System. — An auxiliary system of lighting is provided so that in case the current is, for any reason, cut off from train, the emergency system will automatically light up and remain lighted until the regular lighting is restored.

Door Interlock Signals. — An arrangement whereby the starting signal system is interlocked with the doors, so that signal to start will not reach motorman until all doors in train are closed.

Automatic Coupling. — All couplings between cars are made automatic, including Car, Air and Electrical connections, thus making it unnecessary for employees to go between cars when making couplings.

Safety Gates. — Safety gates are provided at ends of cars that come together and close opening between ends of adjoining cars when coupled, to prevent possibility of passengers falling between cars from station platform.

Bridges. — The space between members of bridges on electric lines, which are close to the track, should be filled in with sheet metal to a height of 8 feet, to prevent passengers accidentally being caught and injured by a member as the car passes by. The inward side should present a smooth surface. Passengers are especially apt to be hit and knocked off the car by a bridge member, when they indulge in the dangerous practice of riding on the running board.

Subways and tunnels should be constructed with niches, spaced every few feet, serving as a safe refuge to workmen from passing cars.

Third Rails. — These should be protected by railings or pits. "DANGER, THIRD RAIL" should be plainly marked on the rail at frequent intervals. In large cities where the traffic is large enough to warrant a large initial expense, underground conduit systems should be used in place of overhead wires. In this case, the connection is made by a "plow" extending down from the car through a narrow space between the two slot rails in the middle of the track

to a T or channel iron supported on insulators in the conduit. This prevents persons from coming in contact with the conductor. Conspicuous warning signs should be placed in subway stations and on elevated system stations, to caution the public of the third rail.

Motormen and Conductors. — Motormen should never talk to anyone on the car while operating it. They should keep a sharp lookout at all times, and act in accordance with all signals given by the conductor to stop and start, unless they know that such action might cause an accident. They should never attempt to traverse a railroad crossing until the conductor has had ample time to look in both directions along the railway, nor until he gives the signal to proceed. They should run slowly and use great caution in passing another car which has stopped to let off passengers who might carelessly attempt to cross the track by walking around the rear of the car. They should also run slowly and carefully at crossroads on main streets and in crowded sections of the city. Motormen should ring gongs or blow whistles continually when rounding curves, at crossings, in crowded sections, and whenever there is danger of persons being hit.

Conductors should never give the starting signal until passengers are safely within the car, nor until passengers have safely alighted from the car. Conductors should get out at every railroad crossing, even if the flagman signals all is safe, and make sure that no train is approaching in either direction. Then, and not until, should he give the signal for the motorman to proceed.

Care should be used by both the motormen and conductors in opening and closing doors. They should not be opened until the car has come to a full stop. Neither should the car be started until the doors are closed. When necessary, conductors should assist passengers in boarding and alighting from cars.

CHAPTER XX

MINING AND QUARRYING

THE hazardous features of coal mining are represented in the danger from falls of roof and coal, and from mine cars and locomotives, fire, coal dust explosions, gas explosions, electricity, and explosives.

The Federal Bureau of Mines, working in conjunction with prominent mining companies, has carried on a great deal of research work in connection with accident prevention in coal mines. The efforts of the Bureau have met with considerable success. The Federal Bureau of Mines has issued many valuable bulletins and miner's circulars which deal with all phases of coal mining hazards. These bulletins have accomplished much toward educating mine owners and managers to cope with the dangers incident to both coal and metal mining.

During the year 1912 there were 4.29 men killed for every 1,000,000 tons of coal mined. Statistics in 1911 indicate that 5.48 men were killed for every 1,000,000 tons of coal mined. The year 1912 thus shows a decrease in men killed over 1911 of 21.7 per cent. For every man killed there are, of course, a great many more seriously injured. The number of fatalities and serious accidents, have, however, been constantly decreasing, due to more concerted effort on the part of mining companies to prevent accidents and educate the miners, and also to the more efficient and effective inspection service offered by state mining departments.

The risk in coal mining is greatest during the winter months. The reason for this is that the air, which enters the mine, is cooled below the temperature of the workings.

It thus dries the mine. This directly increases the danger from explosions and also enhances the possibility of falls of roof and coal.

Classification of Accidents. — The percentage of men killed in and about coal mines of the United States during the year 1912 is given in the following table, compiled by the Bureau of Mines:

	Percentage
Killed Underground:	
Falls of roof (coal, rock, etc.)	41.19
Falls of coal (other than roof coal)	7.58
Mine cars and locomotives	15.34
Gas explosions and burning gas	6.95
Coal dust explosions	1.27
Explosions of coal dust and gas together	4.53
Explosives	5.64
Suffocation from mine gases	0.42
Electricity (shock and burns)	3.22
Animals	0.30
Mining machines	0.42
Machines other than locomotives and mining machines	0.17
Mine fires (burned, suffocated, etc.)	0.47
Other causes	2.29
Total	89.79
Killed in Shaft:	
Falling down shafts or slopes	1.19
Objects falling down shafts or slopes	0.22
Breaking of cables, chains, etc.	0.08
Overwinding	0.08
Other causes	0.72
Total	2.29
Killed on Surface:	
Mine cars and mine locomotives	2.88
Electricity (shocks and burns)	0.38
Machinery	1.27
Boiler explosions	0.04
Railway cars and locomotives	0.59
Other causes	2.76
Total	7.92
	100.00

The more important causes of metal mine accidents are due to falls of rock and ore from roof, wall, and bank; to timbering; careless use of explosives; falling down shaft, winze or stope; cars and haulage system; electricity; fires; and machinery and hand tools. The hazards are

very similar to those encountered in coal mining, except that there is not as much danger from fire and from dust and gas explosions.

The following table, compiled by the Bureau of Mines in 1911, shows how accidents in metal mines have been classified, and the relative hazard connected with the different headings. The percentages are based on men killed, seriously wounded, and slightly injured:

UNDERGROUND MINES

Killed or Injured Underground by:	*Percentage*
Falls of rock or ore from roof or wall	26.96
Timber or hand tools	8.02
Explosives	1.08
Haulage accidents	13.05
Falling down chute, raise, winze or stope	3.33
Run of ore from chute or pocket	3.91
Drilling accidents	5.39
Electricity (shocks or burns)	0.13
Machinery (other than locomotives and machine drills)	2.57
Mine fires	0.11
Suffocation from natural gases	0.08
Inrush of water	0.06
Other causes	14.04
Total	78.73
Killed or injured in shaft by:	
Falling down shaft	0.23
Objects falling down shaft	0.96
Breaking of cables	0.02
Overwinding	0.06
Other causes	0.84
Total	2.11
Killed or injured on surface by:	
Mine cars and mine locomotives	0.60
Railway cars and locomotives	0.19
Run or fall of ore in or from ore bins	0.44
Boiler explosions	0.02
Electricity (shocks or burns)	0.10
Machinery	1.29
Other causes	4.66
Total	7.30

SURFACE MINES

Killed or injured in surface mining by:	
Falls or slides of rock and ore	1.90
Explosives	0.49
Mine cars or locomotives used in mine	1.59

Steam shovels	0.80
Falls of persons	1.33
Falls of derricks, booms, etc.	0.31
Railway cars or locomotives (not used in mine)	0.09
Run or fall of ore in or from bins	0.04
Machinery (other than locomotives and steam shovels)	1.34
Electricity (shocks and burns)	0.04
Boiler explosions	0.00
Other causes	3.93
Total	11.86
	100.00

Electrical Accidents. — On account of the small space, poor light, and dampness encountered in mines, electricity is especially dangerous. Wires are within easy reach, it being frequently necessary to stoop to avoid them. Also, installations of electrical apparatus and machinery are usually of a more or less temporary character; consequently the installations and wiring are completed at the least possible expense and in the shortest possible time. Therefore, little attention is usually paid to the factor of safety, insulation being frequently inadequate or entirely lacking. Careless installations are, however, unsafe and expensive to maintain. Poor ventilation, dust, and falls of roof also contribute to the causes which favor electrical accidents in mines.

Light conditions can be made satisfactory at dangerous points. Limited space can be counteracted by the use of safeguards. Ventilation can be greatly improved. Dust and dampness, however, are elements which cannot be readily eliminated.

If a miner touches live trolley wires, uninsulated wires on machines, metal parts of switches, or live parts of motors, either with his bare hand or a metal tool, he is likely to receive a shock which will cause a severe burn or even death. Metal parts of machines, which have become accidentally charged with static electricity, are another source of electrical accidents. This is caused by failure of the insulation, interference with grounding, and live wires coming in contact with metal parts. It is highly important

that all wires and connections be completely covered with effective insulation. All precautions, which will make conditions safer, should be taken.

Most electrical accidents in mines are the result of the miner coming in contact with trolley wires which are necessarily bare of insulation. All trolley wires should be guarded by an inverted trough constructed of wooden

FIG. 102
Guard for overhead trolley wires in mine.
Courtesy United States Steel Corporation.

boards, or by some other means. This type of guard affords the necessary protection to the miner, preventing any part of his body from coming in contact with the wire. The great danger from trolley wires lies in the fact that the ground is used as a return circuit conductor for the electric current. If the miner's body comes in contact with the overhead trolley wire in any way, it serves as a good conductor for grounding the current. Thus the miner would receive a serious and perhaps fatal shock.

In order to avoid shocks from the metal frames or parts of machines and apparatus, which are not designed to carry any current, they should be effectively grounded. This will prevent them from becoming charged with a greater potential than that of the earth, thus entirely eliminating the possibility of shock from accumulated static electrical charges on these parts of machines or equipment. Shocks of this nature are sometimes received from the frames and metal parts of locomotives and mine cars. The frames of locomotives are connected to the live parts of motors, the current passing through the metal frame to the rail and the ground. In case the wheels of the locomotive are separated from contact with the rails, for any reason, such as might happen from oversanding the rails, the metal parts of the frame will become charged with a dangerous potential. Under these circumstances, a workman might receive just as severe a shock from the frame as from the trolley wire itself. Again, the drawbars of mine cars are connected to the frame of the locomotive, the connection being continuous throughout the entire trip. Therefore, if the locomotive is separated from contact with the rails, for any reason, the charge may extend through the drawbars of all the mine cars in the trip, raising them to the potential of the trolley wire. Thus a workman might receive a fatal shock from the drawbars of mine cars.

Electrical apparatus and machinery require constant inspection in order to maintain a proper factor of safety and to obtain efficient service. Dangerous exposed electrical wires and apparatus are frequently the cause of serious mine fires and explosions. Great care should be taken to make all installations of electrical machinery and apparatus as safe as possible, providing adequate insulation and effective safeguards.

Those who are familiar with electricity should caution those who are ignorant regarding it, teaching them to be careful, instead of encouraging carelessness. Due respect

should be shown for all wires and electrical apparatus. Workmen should keep away from wires, and avoid touching any part of electrical machinery unless their duties require it. They should be cautioned to obtain proper insulation for their bodies before working about electrical apparatus, and to avoid working in a wet place where there is danger of electrical shock. Rubber boots, if in good condition, offer good protection as an insulating medium. Electricians should wear rubber gloves when at work on dangerous circuits. Miners should be cautioned against hitting trolley wires with metal tools or drill steel. For this reason these objects should never be carried on the shoulder when inside a mine. No one should ever wilfully cause a fellow-workman to receive an electric shock. The consequences are always speculative, and they may be fatal.

It is necessary to use the utmost care in handling explosives near electrical apparatus of any kind. A small electric current or spark might readily cause an explosion. Explosives should never be carried in mine cars which are hauled by electric locomotives. The iron fittings of the cars might receive an electrical charge from the drawbars, especially when the motorman is using sand on slippery rails. Explosives should, at all times, be kept as far as possible from any electrical current.

Mine Fires. — An enormous waste of life and property has resulted from mine fires in the past, and there will be much loss in the future until mine owners and managers take more radical preventative measures. Most fires, except those caused by explosions, start in a small way. They could be easily extinguished if proper fire-fighting apparatus were at hand. Fires are almost as much to be feared as explosions, and they often cause more damage. Fires are frequently, however, the direct result of explosions, especially in coal mines. Many fires are caused by carelessness. Others are due to spontaneous combustion of the "gob," i. e., the waste material left in

rooms or abandoned workings of the mine. Fires sometimes start in sulphide ore mines from spontaneous combustion, caused by the heat generated by oxidation of the ore. A serious fire in a coal mine may last for several years. It may be practically impossible to extinguish it before it has caused an enormous loss.

Fires in surface buildings may become dangerous by spreading to the headframes and tipples, thence into the mine itself. Breaker buildings, or other buildings, should not be built over or about the headframes; otherwise, there would be no chance of escape for the miners if this happened to be the only means of exit. The laws require separate exits in coal mines, placed so many hundred feet apart, according to the different state regulations. Where practicable, headframes and tipples should be constructed of steel. If wood is used, the headframe should be in the skeleton form with no housing. Emergency steel trap doors should be placed over the shaft, so they may be shut in case of fire, thereby preventing the fire from entering the mine. Ventilation should be secured, when these doors are shut, by means of an auxiliary conduit entering the shaft below the trap doors, with an outlet situated some distance from the shaft. Wooden buildings should not be constructed within 200 feet of the mouth of a shaft or tunnel. If built within this limit from a tunnel, separate exits should be constructed to connect with the tunnel, with the mouth of the exit located at least 200 feet from any building. If these precautions are not taken, the miners might be suffocated by smoke and gases.

Combustible buildings should be located as far from shaft openings as is consistent with safety and operation. In any case, the buildings should be protected by automatic sprinklers and hose lines. There should be an ample water supply, stored in tanks or reservoirs affording sufficient pressure, with which to fight both surface and underground fires. Buildings within 300 feet of shaft openings should be sprinklered. There should be a sufficient number of

hydrants, with adequate lengths of hose, stationed at the most convenient points. Small hose, which is capable of being directed by one man, is best for underground purposes. Large hose lines should be used on the surface.

The maximum trajectory of a water jet from a hose line under 40 pounds pressure, in an entry or level 7½ feet high, to a point where the center of the spray would strike the floor, is less than 60 feet. Therefore, as no appreciable elevation can be attained for the stream underground, the efficiency of a hose line in a mine is far below what it would be on the surface. The stream cannot be thrown nearly so far. When the fire is in the roof or timbers, the effective distance, under the same water pressure, is less than 40 feet. Thus it will be readily seen that there are many difficulties in the way of effectively fighting a mine fire.

Shaft bottoms and landings should be constructed of steel and concrete to render them fireproof. There should be a water main in the shaft of at least 3″ in diameter, with valves and hose attachments at each landing. Pump-rooms, engine-rooms, motor-rooms, and stables should also be constructed of reinforced concrete. Non-fireproof stables are especially dangerous on account of the rapidity with which a fire spreads in hay and loose straw. Hay and straw should be wet when taken into the mine. Small quantities only should be taken in at a time. It should be stored in a separate fireproof compartment behind locked doors. Open lights should never be allowed in a stable. All underground stables should be equipped with automatic sprinklers.

Fan engine houses and fan cases should be built of fireproof material. If they were built of combustible material, and set on fire, the intake would force smoke, instead of fresh air, into the mine. If fan engine houses or casings are not fireproof, steel trap doors, which can be quickly shut, should be provided.

Fires may be caused by blasts and cave-ins. In coal mines, they are frequently caused by the former. Portable

fire extinguishers should be placed at convenient points near the breast or face. A complete system of water pipes, with taps at every 100 feet and hose lines at every 200 feet, should be placed throughout the mine. This is important for fire protection, and also for the reason that the water may be utilized for allaying dust.

Gob fires, as has been stated, sometimes originate from spontaneous combustion. This is due to overheating by oxidation. If the gob is tightly packed and sealed off, so that no air can drift into it, there will be little chance of spontaneous combustion. Hydraulic filling and flushing will prevent gob fires. Where methane gas is generated in any quantity, it is not advisable to seal off the rooms. In this case, the pillar and stall, or some form of the longwall system of mining, should then be employed.

Mine fires are commonly caused by some defect in electrical apparatus or equipment. Most fires, which are caused by electricity, are due to defective installation and insulation, careless upkeep, and accidents to equipment from falls of roof and other causes. Short circuits, which fail to actuate a circuit breaker or blow out a fuse, may produce sufficient heat to ignite coal or timber. Sparks or arcs may also set fire to nearby combustible material. Even incandescent electric lamps, if the heat be confined, are capable of igniting combustible objects. Inflammable material should never be stored near fuses, circuit breakers, or other apparatus capable of producing a spark or of generating considerable heat. Candles and torches should not be left burning near timbers. Rubbish should not be allowed to accumulate.

Explosions of gas and coal dust usually start fires, although the gases generated by an explosion may automatically extinguish the fire, as these gases do not support combustion. If the ventilation is good, however, the fire may persist and become serious.

Refuge Chambers. — At each division headquarters in a mine, where fire-fighting apparatus is usually kept, it is

advisable to convert the room into a refuge chamber. This chamber should be made as nearly fireproof as possible. It should be equipped with three sets of fireproof doors. There should be telephone connection to the surface through a drill hole, not through the shaft. The room should be stocked with canned food, drinking water, oxygen tanks, first-aid kits, and other useful material. The room should be provided with a separate ventilating system. Miners who might become entombed by an explosion, or cut off from escape by a fire, could then seek this refuge chamber, remaining fairly comfortable until rescued. Direction boards, indicating the way out and the way to a refuge chamber, should be conspicuously placed about the mine. These indicators will prevent anyone becoming lost through fear and excitement.

Fire-fighting Equipment. — The fire-fighting equipment should consist of water-pipe lines, hydrants, hose, taps, fire pumps, tanks or reservoirs, emergency fire doors and stoppings, ventilating fans, portable fire extinguishers and buckets, breathing apparatus, portable electric lamps, and telephone and alarm apparatus. All portable equipment should be maintained in its proper place, ready for instant use. Special attention should be given to the maintenance of the breathing and rescue apparatus.

Fire Precautions. — The following fire precautions, prepared by the Bureau of Mines, should prove useful:

1. Do not use lumber where brick, concrete, or other non-combustible material should be used. These will give protection against fire, and the extra first cost will be offset by fewer repairs and cheaper insurance.
2. Lay water lines to all parts of the mine. The water may be used to allay dust as well as to fight fires.
3. Have at hand fire-fighting appliances and breathing apparatus; they may save your mine.
4. Organize your miners to fight fire.
5. Assume that a fire may break out at any point at any time. A fire may start while repairs are being made.
6. Always consider the possibilities of escape for the men.
7. Carry on competitive fire drills to interest the men, so they will be ready in an emergency.

8. Use closed or safety lamps instead of open lights in a coal mine. Portable electric lamps are better still.

9. Engage competent electrical engineers to install your electrical plant.

10. Take all possible precautions against short-circuiting.

11. Do not enclose an active mine fire until other means of extinguishing the fire have been exhausted. First, have all the men leave the mine, except those needed for this work.

12. Never reverse the ventilation, when fighting a fire, unless you know what dangers may result.

Fire Brigades. — In order to successfully fight a mine fire, an efficient fire brigade and patrol should be organized at each mine. The organization should be patterned after that outlined under the chapter on "Fire Brigades." Drills should be held every week. Members of the brigade should be supplied with cloth fire maps showing the locations of all shafts, entries, levels, headings, cross-cuts, raises, and winzes. The maps should also show all pipe lines, hydrants, taps, pumps, sumps, ventilation system, fire-alarm signals, overcasts, and doors. Members should also be supplied with division maps showing the detail of the mine workings and the fire-fighting apparatus.

Gas Explosions. — Gas and air mixtures, which contain between 5 and 11 per cent of methane gas, are readily ignited by electric sparks or open lights, and sometimes by incandescent electric lamps when they are broken. Therefore it becomes necessary, in a gaseous mine, to inclose all motors and switches (unless oil switches are used), and to abandon electric haulage systems. No machinery should be left in such a condition that it might readily cause a spark. Falls of roof frequently wreck trolley wires and feeder systems, causing sparking and explosions.

Motors should be so constructed that they will be explosion proof. They should be so enclosed that an explosion within the casing cannot ignite the gas and air mixture outside the casing. The relief of pressure, resulting from an explosion within the casing, is usually accomplished by an opening or valve, so constructed that the products of the explosion will be cooled before escaping.

This is effected by passing the gases, resulting from the explosion, through a series of metallic baffle plates or wire screens. These remove the heat from the escaping gases by means of conduction. This is the same principle which governs the Davy safety lamp. The protective device should be so designed that no flames can be forced through it by an explosion within the casing, and so that no dust can enter, or if allowed to enter, it should be prevented from being discharged while ignited. These devices should be very strongly built and protected from injury. They should be so designed that they cannot be detached from the motor unless the motor is rendered inoperative. They should be capable of absorbing a large amount of heat in a very short time. The metal should be a good conductor of heat. Enough metal should be exposed to the flame of an explosion to offer as large a heat absorbing surface as possible under the circumstances.

Casings for motors should have as few openings for safety devices as possible. Electrical conductors, which enter the casing, should be bushed with hard fiber insulation. All joints should be tight. The amount of unoccupied space within the casing should be as small as practical design will allow. The starting boxes of motors should receive the same protection as motors.

Explosion-proof casings for switches are also designed on the same principle as the safety device and casing for motors. Oil switches should be so designed that the oil cannot leak out or be spilled in any way. They should never be left unfilled through neglect. The oil should cover the contact for at least one inch above its upper extremity. Oil will not evaporate to any extent, provided proper oil is used, nor will the oil deteriorate as fast as the contacts. Oil switches are usually preferable to encased switches for mine use.

Safety Lamps. — The functions of the miner's safety lamp are to give light and to detect the presence of methane gas, at the same time preventing the ignition or explosion of gas outside the lamp. Improper use and care of safety

lamps have been the cause of many fires and explosions. Explosions frequently result from improper assembling of the lamp. Parts are often misplaced or unadjusted. Pull bars are sometimes found removed, rendering the lamp as dangerous as the ordinary open lamp. Cases occasionally occur in which the miner removes the gauze from the lamp. As the safety principle depends upon keeping the flames of the lamp within the gauze, the heat being conducted away by the gauze, this is obviously a most dangerous practice.

Lamp foremen should be appointed to pass upon the condition of all safety lamps each day before they are issued to the miners. Lamp foremen should be held responsible for the condition of all lamps. Each workman should also be required to personally examine his lamp before going underground. No defective lamps should be allowed to reach the interior of the mine. The foreman should lock the lamps before they are issued. Lamps should never be unlocked underground.

Great care should be taken to keep the lamps clean and in good condition. It is upon these factors that their safeness depends. The atmosphere in the working place should be tested for gas by means of the flame. Where gas is suspected, tests should be frequently made. If gas is present, the length of the flame will be increased. The elongation of the flame is a measure of the proportion of gas present. The "cap" or non-luminous flame is most suitable for testing the proportion of gas up to 4 per cent. A lighted safety lamp should never be placed in an atmosphere containing over $5\frac{1}{2}$ per cent of explosive gas.

The following rules for lamp foremen or inspectors, prepared by the Bureau of Mines, should be followed:

1. The framework of the lamp should be rigid and well made, so that it will not get out of shape when roughly handled.

2. If the lamp has a glass chimney, the upright rods should be of such number and so spaced that a straight edge or ruler, placed against any two adjacent rods, will not touch the glass.

3. If a lamp has no bonnet, the gauze should be protected with rods in the same manner as the chimney, as indicated above.

4. The lock should be such as will require, when locked, a special device for unlocking.

5. The glass chimney should have a smooth and even wall throughout, should be of the best quality, and should have its ends ground truly parallel and at right angles to the axis of the chimney; that is, if rulers are placed on each end of the chimney, the rulers should be parallel. The chimney should bear the trade-mark of the manufacturer.

6. When the lamp is assembled, there should be no openings between the outside and the interior of the lamp except those in the gauze or other heat-absorbing material, such as a perforated cylinder in which the size of the perforations corresponds with that of the openings in the gauze.

7. The handle of the lamp should be either an open ring or a hook, strongly made and not easily bent with the hand.

8. The construction of the lamp should be such that its parts are made in standard, uniform sizes, fitting so intimately that, should any part be omitted in assembling, its absence would be detected by the most casual inspection.

9. There should be an expansion ring, or equivalent device, used with the glass chimney, so that the chimney, when heated, can expand without breaking any part of the lamp.

10. In the selection of a safety lamp, the lamp foreman should carefully examine each of the disassembled parts to discover defects or improper construction. If the lamp does not meet the above requirements, it should be rejected.

Some of the more common errors in assembling safety lamps, as outlined by the Bureau of Mines, are as follows:

1. Leaving out one or both gaskets, or using broken gaskets.
2. Placing gaskets in underfed lamps so as to exclude the air from below.
3. Leaving out one of the gauzes in double-gauze lamps.
4. Placing on top of the glass an expansion ring designed to be placed under the glass.
5. Placing the expansion ring upside down, thus destroying its usefulness.
6. Failing to screw the bowl (fount) sufficiently to make a tight fit between the glass globe and the gaskets.
7. Leaving out the igniting device without plugging the stem hole.
8. Leaving off the deflection rings that prevent air from blowing directly into the lamp.
9. Leaving off the shield or bonnet when the lamp is to be used in a strong current of air.
10. Placing a defective gauze in a lamp.

The following precautions regarding the use of safety lamps, prepared by the Bureau of Mines, should be strictly observed:

1. Be sure the lamp is locked before taking it into the mine.
2. Examine it carefully yourself to see that it is in good condition.
3. Do not carry a key or other device for unlocking the lamp.

4. Do not carry matches into the mine.

5. Do not attempt to open a lamp within a mine except at a regular lamp station, where the rules permit lamps to be opened and relighted.

6. Do not set your lamp on the ground; it may be upset and extinguished, and the glass globe may be broken. Hang the lamp on a timber.

7. Never use a lamp that has dirt or oil on the gauze.

8. In testing the lamp in the lamp-room tester for its safeness in gas, hang it by the handle.

9. In testing for the presence of gas in a mine, hold the lamp firmly by the bowl or fount.

10. In testing for gas, be careful to prevent dripping water from striking the glass globe.

11. Do not allow the flame to smoke; soot may fill the gauze.

12. Before entering a room or a "tight end," examine the flame of your lamp. As you advance, make frequent tests for gas. Make frequent tests during the shift, and always before and after a blast.

13. To avoid being left in the dark, fire bosses should carry two lamps, one for traveling and one for testing, unless the testing lamp is equipped with an internal igniter.

14. If possible, avoid testing for gas pockets while shots are being fired; otherwise, the flame of your lamp may be driven through the gauze and the external gas ignited.

15. When gas flames in your lamp, withdraw the lamp slowly and carefully. If the flame goes out, retire to fresh air before attempting to relight it.

16. If your lamp flames and the wick flame goes out, be sure to examine the gauze, because the gas may be burning within the gauze. To put out the flame, shut off the air supply, or take the lamp to fresh air if near at hand. Do not try to smother the flame with your clothes.

17. Lamps that have not been used for some time often have rusty gauzes, hardened wicks, and are often gummed with oil. They should not be used in this condition.

18. Having detected gas, do not repeatedly put your lamp into it, but arrange for the removal of the gas by ventilation.

Portable Electric Mine Lamps. — The latest types of electric mine lamps are far superior to the common safety lamps. The only disadvantage is that they do not detect gas. The lamp is worn on the cap, thereby allowing the miner the free use of both hands at all times. The lamp should be so constructed that the bulb cannot be broken before the filament ceases to glow.

Tests on electric mine lamps, carried on by the Bureau of Mines, have conclusively proven that sparks from an ordinary miner's electric lamp are not capable of igniting gas. This statement is based on the assumption that the

potential does not exceed 6 volts, nor the current .1 ampere. These limits are rarely, if ever, exceeded in such lamp outfits. There will be little chance of a short circuit, provided the equipment is properly constructed and maintained in good condition.

Ventilation. — Upon the proper ventilation of a mine depend the health and safety of the miners. Good ventilation at the face is absolutely essential. Poor ventilation allows gas, which is a constant menace to life and property, to collect in the mine workings. Good ventilation depends partly upon the co-operation of the miners themselves. Such an act as leaving a trap door open may render useless the best system of ventilation. The system should afford sufficient fresh air for all the men and animals in the mine. It should also be capable of quickly diluting and removing gas from workings.

The minimum quantity of fresh air should not be less than 200 cu. ft. per minute for each person employed in a coal mine, nor less than 500 cu. ft. per minute for each animal. Not more than 75 persons should be employed at the same time in any one split of air current. Measurements of the rate of flow of air should be made daily at the inlet and outlet airways, and also at or near the face of each gangway. The air current should not be split below the point where the velocity of the air would become less than 100 ft. per minute. This velocity is necessary in order to properly remove any gas which might otherwise collect. All air gauges and anemometers should be frequently tested and inspected.

Fans should be constantly run day and night. If shut down for any reason, or if they are not operating at speed, the men should be immediately withdrawn from the mine. Fan motors should be on individual circuits, so that their operation will not be stopped by a short circuit to other machinery. Fans should not be located over a shaft, nor in front of a slope or entry to a mine. Fans should never be reversed while the men are in the mine, except when

they are entombed, and then only in case of necessity. No one should reverse a fan at such a time unless he obtains permission from those in authority, nor unless he has a full knowledge concerning the consequences which will result.

The air shaft should be kept clear of ice in cold weather. It should be frequently examined, otherwise it may reduce or entirely shut off the air current. If the weather be cold, the intake air may be preheated by exhaust steam. Each miner should be supplied with a cloth map of the ventilating system. A large map of the system should be posted upon a bulletin board at the surface. This will teach the miners the course of the ventilating current. Airways should always be kept free from falls of roof and other obstructions, otherwise the current will be considerably reduced.

Double doors should be used at the mouths of cross entries, so that a door may be closed all the time as a trip passes through a cross entry. All doors should be so counterweighted that they will close automatically. All overcasts and stoppings should be of non-inflammable material. A supply of curtain material, and material for stoppings, should be kept on hand in the mine for use in an emergency. Miners should be instructed to report the torn or poor condition of curtains or brattices, broken doors, and other devices. Trappers or door boys should never be allowed to block doors open. When opened, the doors should always be held in that position by hand. They should always be closed again as soon as possible. Regulators should be left in the position in which they are found. They should only be changed by the fire boss or by the mine foreman. Rooms should never be turned ahead of the air, — that is, beyond the last open breakthrough which carries the air current. Old workings should be either ventilated or sealed off with solid fireproof dams or permanent stoppings of brick or concrete.

All miners should be removed from a gaseous district,

or from near a large volume of standing gas, before the gas is removed. In case of a fire or an explosion, miners should invariably follow the intake airway in going out of the mine, as the return airway would be choked with gas and smoke. Under no circumstances should a miner cross a "dead line." A dead line should be indicated by a danger signal, placed at the entrance to a dead or abandoned working by the fire boss or other official.

Workmen are frequently poisoned by an accumulation of gases generated by explosions in blasting. If natural ventilation is inadequate, artificial ventilation should be employed. Gases form in dangerous quantities when dynamite is not properly detonated. Miners should not be permitted to remain in an atmosphere which will not support the flame of a candle.

Checking Men in and Out of a Mine. — Bulletin boards should be maintained at the surface upon which the fire boss should make a daily record of the condition of each workplace. Each miner should examine this board before going into the mine. Miners should not be allowed to enter the mine until they have received a metal check designating their number. These checks should be kept on a check board in charge of an official. If conditions at the place where the miner is to work are unsafe, the fire boss should not place the miner's check upon the board, but he should leave a special check or a note stating the unsafe condition. Miners not finding their checks in place upon the board should not be allowed to enter the mine until they have received special instructions from the fire boss or mine foreman.

Shafts. — Compartments in which men are hoisted should be at least $5\frac{1}{2}$ by $5\frac{1}{2}$ feet in the clear. The top of each shaft should be guarded with a substantial railing at least 4 feet high, with a toeboard 6″ high, and two intermediate horizontal members between the two. The entrance should be guarded with a gate. The shaft should be well lighted at all times at the top, bottom, and at each

landing. Gates should be installed at all shaft landings, including the bottom entrance. They should be so arranged that they cannot be opened until the cage is at a given landing. All gates should be at least 5 feet in height. Pools of water and mud should not be allowed to remain on the floor of headframes or landings within 10 feet of the shaft.

Each shaft should be equipped with an efficient electrical signaling system. Copies of the signal code should be placed at each landing, and also in the hoist house. The following uniform general code is recommended:

1. Start or stop................one bell.
2. Lower......................two bells.
3. Prepare to hoist men........three bells.
4. Hoist men..................four bells.

Shaft Sinking.—Shaft sinking is always a dangerous process. Drillers and muckers are constantly subjected to the danger of falls of rock from the walls and from buckets. Other objects may fall into the shaftway. Miners themselves are occasionally killed by falling down the shaft. Accidents in hoisting and lowering men, due to the breaking of a cable or to overwinding, occur from time to time. Accidents from the careless and improper use of explosives are common.

It is important to keep the walls of the shaft scaled of loose rock as the process of sinking progresses. As it is impracticable to timber or concrete a shaft within a considerable distance from the bottom, as the shaft is being sunk, on account of the damage which would otherwise be done to the structure when blasting, there is always danger from falls of loose rock and from flying rock. For the protection of miners, in this case, a suspended steel platform or bulkhead should be used. This bulkhead should be kept within about 15 feet from the bottom of the shaft. Holes must be provided for a manway, and for hoisting and lowering the buckets and pump. Chain ladders with iron rungs should extend from the last fixed

section of the main ladder to the bottom of the shaft, serving as a means of escape for the miners. A chain ladder will not ordinarily be seriously damaged by blasting.

Tunneling. — The most serious dangers encountered in tunneling are from falls of rock or ore, explosives, transportation of men and ore, electricity, fire, flows of water, and from gas. The foremen should see that the work is carried on in a safe way. They should warn the men of any danger that is likely to arise during the shift.

The worst danger is from falls of rock and ore. The roof of the tunnel, drift, or cross-cut, should be properly supported, where necessary, as the work progresses. A sufficient supply of timber should be constantly kept on hand to permit the timbering to be completed as the tunnel advances. Where the roof is at all dangerous, the timbering should be completed as soon as possible, even if it causes some delay. An improperly supported roof is likely to claim the lives of miners at any moment, and without warning. The roof should be carefully examined and constantly watched. Any dangerous loose rock will thus be discovered. Loose rock should be immediately barred down or properly supported. Where the roof consists of loose ground, substantial lagging should be provided to prevent loose pieces from falling on the men.

Miners should be forbidden to ride on loaded trips. They should be cautioned against jumping on or off moving cars. They should be warned to keep their hands and feet entirely within the car when in motion, and also to watch for obstructions. Care should be taken, in placing tools in the cars, to see that no metal parts come in contact with trolley wires. Drivers should be forbidden to ride on chains.

Overcharging holes with explosives often causes shattering of the roof. This loosens rock which will later be likely to fall on the men, if not barred down or supported. It is important to test the roof after each blast before the miners are allowed to return to work. The correct way to test

the roof is by striking it with a pick or a heavy stick, while the hand is placed on the part of the roof being tested. If any vibration is felt, the roof is unsafe. That part which vibrates should be immediately barred down or supported. Where the roof is out of reach, the vibration, if there is any, may be felt by pressing a stick against the doubtful part as it is being struck. Workmen should be taught to examine the roof in passing in or out of the workings, reporting any unsafe conditions.

Stoping. — Much that has been described under tunneling is also applicable to stoping. Like tunneling, the most serious danger is from falls of roof. No bellies in the roof should be allowed to remain unsupported. Timbers which are taking too much weight should be reinforced. Workmen should not be allowed in old stopes where the timbers show serious signs of failing. Raises and winzes should be guarded with railings and covers. There are several different methods of stoping, some safer than others, but the safest method is not always the most economical. Swelling ground should be carefully watched. The responsibility should fall upon the foremen to maintain safe conditions.

Timbering. — Many accidents in timbering shafts, stopes, and tunnels are unavoidable, owing to the inherent hazards of this work. Shaft timbering is especially dangerous. Bruised hands and limbs from handling heavy timbers are common. Timbermen are frequently injured by falls of roof and walls. They are often seriously hurt by falling themselves. Practically the only safeguard is personal caution.

Ladders. — Every mine and isolated underground working should have at least one shaft equipped with a substantial ladder of sufficient strength to hold a weight of 400 pounds for each 8 feet of its length. Each section of the ladder should be securely fastened. No ladder should be placed vertically or inclined backward. Ladders should be inclined at an angle of 15 degrees from the

vertical. The sections should be connected with steel straps or bolted rods. A landing should be placed every 20 feet vertically. These landings will prevent a long fall, if a person should slip. They also afford a chance for the miners to rest when climbing, as well as prevent material or rock from falling. Ladders should be regularly inspected for defects.

Transportation. — Cars which are hauled up inclines should be equipped with a safety sprag or drag, which will prevent the trip from rolling down the incline in case the cable should break. Cars should be provided with automatic coupling devices. The wheels of cars should be protected with a housing or plow guard to prevent them from running over a workman's body if he should slip on the track. The underground transportation system in a large mine should be protected with automatic block signals, similar to the system used by the railroads. Larries should be provided with a covered platform, to protect the miner from falls of coal. Trip cars for workmen should be connected with safety chains, which will hold the cars together in case the couplings should break.

Hoisting Equipment. — All mine hoists should be equipped with an efficient brake, and also an additional safety device for stopping, such as a friction clutch or an auxiliary brake. The hand or foot levers for operating the brakes should be placed within immediate reach of the operator, that he may quickly stop the hoist in an emergency. Each hoist should be provided with a device to prevent overwinding. All parts of the hoisting equipment, including the cables, should be inspected daily. All hoisting cables in vertical or inclined shafts should have a factor of safety of at least 10. Spliced cables should never be used for hoisting. Cables should be securely fastened to the drum of the hoist, with at least two full turns about the drum when the cage or skip is at its lowest point of travel. Where cables are attached by means of a thimble, the end should lap back at least 18″, being fastened by

at least 3 clips. All cable hooks should be fastened with a spring clasp or snap. Hooks and bails on buckets should be of sufficient strength, kept in good condition, and never allowed to wear too thin.

Cages. — All cages used for hoisting men should be completely encased on the unused sides, with a collapsible gate on the entrance side. (Fig. 103.) Cages should be provided with substantial steel covers. These may be arranged to slide upward when carrying long tools, pipe, and timber. Each cage should be equipped with an efficient safety device which will prevent the cage from falling in case the cable should break. The safety device should be inspected and tested at least once a week.

Change Houses. — Change houses are necessary for the health of the miners. They should be kept in a clean, sanitary condition. They should be properly heated and ventilated, and well lighted. Shower baths, lavatories, wash basins, and drinking fountains should be installed. Lockers in the dry room should be provided for each workman. The dry room should be so heated that the miners' wet clothes will be thoroughly dried before the next shift.

First Aid and Rescue Organization. — One of the most important features of mine safety work is a First Aid and Rescue Organization. The hazards of the mining industry are so great that it is essential for every mining company to interest itself in this work. It is seldom that a doctor can arrive on the scene of an accident within half an hour, and it is frequently two hours or more before he appears. Thus a well trained first aid crew can do much toward alleviating the suffering of victims until the doctor arrives.

The men should be thoroughly trained and educated in rescue work. Helmet teams should be organized. Practice drills should be held periodically. The Bureau of Mines maintains a number of cars, fully equipped with material and safety devices, in charge of trained crews of mining engineers. These cars are assigned to certain dis-

tricts of the United States, over which they are constantly traveling from one place to another, educating the miners at each mine in first aid and rescue work. The work-

Fig. 103
Improved steel cage for hoisting men in shaft. Enclosed sides, collapsible gates, steel cover, and effective safety device.
Courtesy Traylor Engineering & Mfg. Co.

men are educated by means of illustrated lectures and talks, and by actual demonstrations. Miners manifest considerable interest in this work, realizing that it is done for their benefit; consequently, much good is accomplished.

Quarrying. — The most important causes of quarry accidents are due to the careless handling of explosives, falls or slides of rock, falls or slides of overburden, falls into the quarry, falling booms of derricks, falls from derricks, electricity, haulage accidents, and accidents from hand tools.

All quarries should be surrounded with a substantial railing at least $3\frac{1}{2}$ feet high, located at least 6 feet from the edge of the quarry. Workmen should never be allowed within this railing, except at entrances to the quarry. Footpaths should be kept free from all loose material, such as scrap iron, ropes, cables, and timber. Derrick platforms should be completely guarded with a double railed iron pipe fence. This affords a safe place for the derrickman to stand while directing operations.

Ladders, leading to the bottom of quarries, should be employed only between the lowest bench and the bottom. Suitable steps should connect all other benches. Both benches and steps should be protected with a double railed iron fence. This affords a safe means of travel to and from the bottom of the quarry. Where ladders are used, they should be substantially built, securely fastened, maintained in excellent condition, and frequently inspected.

The edge of quarries should be trimmed of all loose material and overburden. All loose stones, which are likely to fall into the quarry, should be removed. The quarry should be so excavated that there will be no serious overhang on any wall. Loose blocks should be blasted down before excavation proceeds.

MINING RULES

Shafts, skips, cages, and cables:

1. All shafts should be inspected at least once a week. All ore and dirt should be removed from sets and dividers. Lagging, timbers and guides should be examined for defects.

2. Automatic gates should be placed at the collars of all shafts and at all underground shaft openings.

3. Landings in permanent ladderways in shafts should not be placed over 20 feet apart. The opening at each level should be protected by a trap door, to prevent material falling into the ladderway.

4. Dirt and ore should not be allowed to accumulate at collars or landings.

5. Ladder rungs should be of iron. Ladders should be maintained in good condition and frequently examined. They should extend at least 3 feet above all landings. Ladderways should be tightly boarded off from the skipway.

6. Riding on skips should be prohibited, except for the purpose of inspecting the shaft, in which case the engineer should be notified.

7. Man cages should be equipped with an approved form of safety device to prevent the cage from falling in case the cable should break. These devices should be inspected daily, and tested at least once a week, records being kept of inspections and tests.

8. Man cages should be enclosed and roofed. No tools or timber should be carried on a cage when hoisting or lowering men.

9. When men are being raised or lowered, two operators should be at the hoisting engine.

10. No one should be allowed to attempt to enter or leave a cage until it has come to a stop.

11. Never ring the signal for hoisting or lowering. Use call bell or telephone to call the cage.

12. No one should be allowed to ride on top of the man cage.

13. Cagers should never leave a station until the gate (unless automatic) has been properly closed.

14. Cagers should not allow the men to overcrowd the cages.

15. All hoisting engines, cages, skips, sheaves, and cables should be inspected daily by a competent engineer.

16. All pipes in the shaftway should be securely fastened. Steam pipes should be covered with insulating material.

17. Hoisting should be stopped when men are working in a hoisting compartment of a shaftway. All men working below should be notified.

18. When shafts are being sunk, doors should be placed at the dumping platform to close the shaft opening as the bucket is being dumped, to prevent ore and rock from falling down the shaft.

19. A substantial bulkhead should be provided for the protection of the men working at the bottom of the shaft.

20. Electrical equipment for signals should be inspected at least once each week.

21. Signals should be given only by cagers and skip tenders, foremen, mine captains, and landers on surface.

22. Crossheads should be provided for buckets in vertical shafts. Shafts, in which buckets without crossheads are used, should be smoothly cased to prevent bucket catching timbers.

23. Where two ladders are joined end to end, they should be in alignment. The rungs at the joint should be properly spaced.

24. Ladder stringers should be spaced at least 12" apart in the clear. The rungs should be placed at least 4" from the wall and timbers to afford sufficient toe room.

25. Broken and defective ladders should be immediately reported.

26. No unlicensed engineer should be permitted to operate an engine.

27. Men should be forbidden to throw tools, steel and other material
a manway.

28. Drill steel, timber and other material should not be placed w
6 feet of the collar of any shaft opening, raise or winze.

Timbering:

1. Headings should not be carried too far ahead of timber. Miners sl
thoroughly test and trim the back of headings at the beginning of every
and after every blast. If the back is loose, it should be trimmed and se
with props until it can be permanently timbered.

2. If timber is noticed to be under unusual strain, it should be prom
reinforced. The foreman should be immediately notified.

3. When conditions, which indicate danger, are noticed, the foremen
all fellow employees should be notified. They should always be warned in
of crushing timber, caving ground, unusual volume of water or smoke.

4. When work is completed, all protruding nails should be removed
timbers. All loose timber and other material should be removed.

5. Timber and other material should not be hoisted or lowered throu
shaft compartment or raise that contains a ladder.

6. Timber should follow as close as practicable to the breast of drifts
openings. In soft ground, sets should be placed in position as soon as the
sufficient room; the roof should be secured by poles resting on a cap and set
holes at the top of the breast, thus forming a lagging. All loose dirt on back
sides should be carefully trimmed.

7. When timbering a stope or raise, special care should be given to the
forms and staging. When raising, stage poles should be placed about 2½
apart.

8. Drill holes should be so placed and loaded that shots will not disl
timbers in place.

Tramming:

1. When power is used for tramming, no one other than the motorman
brakeman should be allowed to ride on underground tramcars.

2. Explosives should not be transported in trips hauled by an ele
trolley.

3. Underground locomotives should be equipped with red lights and a
matic gongs which will ring when the train is in motion.

4. Underground trolley wires should be guarded by inverted troughs m
of boards. Trolley wires should also be guarded at chutes, drifts, and s
openings.

5. Where more than one motor trams to the same shaft, an automatic b
system of signaling should be installed.

6. Trammers should not leave cars at or near switches or crossings in
a position that they will not clear motors or cars which may pass by on ano
track.

7. Loaders should not leave chutes until they are properly closed.

8. Chutes to skip pockets at stations should be guarded by a grating
substantial railing.

9. Every trammer should keep a light in front of or above his car at
times when the car is in motion.

10. Cars should never be allowed to move or roll to a position without a trammer. The trammer should have his car under his control at all times. When at rest, the position of the car should be indicated by a light.

Hoisting Engineers:

1. No employee, other than the hoisting engineers, should be allowed in the engine room unless his duties require him to go there.

2. Hoistmen should not leave the engine room without securing a competent substitute who is familiar with the bell signals.

3. Machinery and hoisting cables should be examined at the beginning of each shift.

4. When repairing engines, see that the valve on the steam line is closed and padlocked. Never start the engine until you know that the shaftway is clear and that there are no men in the hoisting compartment.

5. If you do not clearly understand a signal, never fail to wait until it is repeated before hoisting or lowering.

6. Do not hoist or lower men at excessive speed. Have your engine under absolute control at all times.

7. Never hoist or lower men unless there is an assistant with you.

Miscellaneous:

1. Traveling about unlighted stopes or drifts without a light should be prohibited. Always carry matches and a candle in addition to a lamp.* If you are unable to light your lamp or candle, call for help. Remain where you are until assistance arrives.

2. Never stand on loose ore over a raise or chute. It may slide and draw you in.

3. Shift bosses and sub-bosses should make certain that their men are familiar with all exits from their working places to the surface.

4. When you go off shift, never leave a candle or lamp burning in the mine.

5. See that all openings, holes, and chutes are covered with planks or a grating, or guarded with a railing.

6. Before going off shift, all tools should be left in their proper places.

7. Always seek a place of refuge when you see a car approaching.

8. Never leave food scraps about the mine. Place them in the receptacles provided for refuse.

9. Before blasting, drillers should remove their machines, tools, and hose a sufficient distance to escape injury.

10. Pickers who are working in milling pits should wear life belts and ropes tied to a bar in the bank above. Never work over pits unless this precaution is taken. Belts and ropes should always be carefully inspected before use.

11. Never touch an electric wire of any kind. Never allow tools which you may be handling or carrying to come in contact with a trolley wire.

12. Never touch or go near explosives unless you are authorized to do so.

13. Keep out of old and abandoned workings.

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* Matches should not be taken into a coal mine. This rule applies to metal mines.

CHAPTER XXI

EXPLOSIVES

ALTHOUGH enormous quantities of explosives are being daily used in mining and engineering operations, a considerable proportion of persons engaged in handling them have a very imperfect knowledge of their character, qualities, and safe methods of using them. This is not only a menace to human life and property, but leads to an important waste of material. Workmen become so accustomed to handling high explosives that they have little or no apprehension of the danger involved from incautious and improper use of these powerful agents of destruction. As a result of lack of knowledge and of carelessness, many exceedingly dangerous practices, which entail fatal consequences, are indulged in.

The use and handling of explosives should be under the direct supervision of men of wide experience in this line of work. Explosives should never be placed in the hands of an uneducated or inexperienced workman until he has served a sufficient apprenticeship, which will have enabled him to become thoroughly acquainted with the safe methods to be pursued. Stringent rules should be strictly enforced by foremen and others in authority.

Several hundred different explosive compounds are recognized in Europe, while in this country their introduction has been slow and commercially unsuccessful. Some of them are superior in point of safety to our common dynamites. Practically the only explosives in general use in this country are black powder (gunpowder and blasting powder) and several ordinary varieties of dynamite.

Properties of Gunpowder. — Gunpowder is a mechanical mixture of 75 parts of potassium nitrate (niter or saltpeter), 15 parts of charcoal, and 10 parts of sulphur.

The proper color of good gunpowder or blasting powder is a uniform dark gray or slaty hue. A dead black or decidedly bluish color indicates either the presence of too much charcoal or an excess of moisture. Gunpowder should show no difference of color when crushed, and no sharp angular fragments should be visible before crushing. On pressing the powder between the fingers it should not crackle, nor should it crush easily under such pressure. It should not crumble under this test, but should fall to pieces in angular fragments. The size of the grains should be quite uniform, and there should be no dust when new. It should leave no color, which would indicate the existence of meal powder or too much moisture, when poured over the hand or paper. Single bright spots, or bluish-white spots, show that the powder has been damp, causing efflorescence of saltpeter, which destroys the uniformity of composition of the explosive and renders its action unreliable. As a rule, powder has not suffered from dampness if no efflorescence of saltpeter has taken place. Damp powder can be restored by drying it in the sun or in a well ventilated room.

A blow of copper on wood rarely explodes gunpowder, a blow of wood on wood never, but a blow of wood or copper on stone has frequently exploded it. Burning bodies only ignite gunpowder when they are very hot. This is well shown in attempting to ignite blasting powder with a match. As long as there is an ordinary flame, the powder will not ignite, but as soon as a narrow pointed flame issues it ignites instantly. A gas flame will only ignite powder after it has acted upon it for a few seconds. Sparks from stone or steel easily ignite powder. An electric spark ignites powder only when the discharge is delayed by the interposition of a bad conductor. An electric current will explode gunpowder only through the heating of a resistance wire in the circuit. Good powder,

ignited on a piece of white paper, burns rapidly away, leaving no residue. If black spots are found, they indicate an excess of charcoal, or an imperfect mixture of the ingredients of the powder. Yellow spots, remaining on the paper, indicate an excess of sulphur; and if any holes have been burned in the paper, it indicates an excess of moisture. or some other imperfection in the powder. Gunpowder cannot be detonated.

Dynamite. — Dynamite is the most widely used explosive in the world. It is made by using an absorbent, commonly called a "dope," which takes up the nitroglycerine, holding it after the manner of a sponge. A suitable dope should possess a cellular structure, so that the nitroglycerine may be subdivided into minute globules, each globule being held separately in its own cell, completely isolated from every other one. In this condition, its sensitiveness is greatly reduced, depending upon the amount of nitroglycerine absorbed.

There are certain requirements which dynamites should fulfil, and it is the duty of all persons, using or handling them, to see that they do not fall short of the proper standard. Good dynamite should not feel greasy. There should be no trace of nitroglycerine inside the wrapper of the cartridge. In order to test this point, lay one of the doubtful cartridges on a sheet of clean brown paper in a room heated to 60 or 80 degrees F. for a period of 12 hours. If the cartridge has begun to leak nitroglycerine, this will be shown by an oily discoloration of the paper. Properly made dynamite should be proof against leakiness under normal conditions of temperature and moisture. To test its quality in this respect, two separate determinations should be made: First, freeze and thaw samples of dynamite three successive times, testing for leakiness as explained above. Second, expose samples to a temperature of from 85 to 90 degrees F. for six consecutive days and nights, again testing for leakiness as above. In neither case should any trace of free nitroglycerine be seen on the brown paper.

Like nitroglycerine, dynamite is most sensitive to shock or friction at just above its freezing point. According to the character of the dope used, it freezes at from 42 to 46 degrees F. It is nearly, if not quite, insensitive to shock when frozen, but not entirely so to friction. Cartridges which are broken when frozen, are subject to explosion from molecular disturbance of the nitroglycerine crystals. Ramming sticks of frozen dynamite into a hole is attended with the same danger. Explosions of frozen dynamite may be due to the friction of long crystals of nitroglycerine with films of unfrozen nitroglycerine. Frozen dynamite is not incapable of being detonated, especially if very powerful detonators are used. Any efflorescence, whitish film, or incrustation on dynamite cartridges indicates either that the dynamite itself contained an excess of moisture in the dope, or (what is more likely to be the cause) that it has been subjected to an excess of dampness in transportation or storage. In either case the incrustation is due to dissolving out the nitrate of sodium or potassium. This has consequently destroyed its homogeneity. Such dynamite is almost always leaky, or will soon become so. It is unreliable, and may fail to explode in blasting. It will produce noxious fumes if it does explode. Its power as an explosive has also been reduced, so that it possesses the disadvantages of being dangerous to handle, unreliable as a blasting agent and, at best, uneconomical. It should not be used, but should be destroyed. Exposure to the rays of the sun, especially if transmitted through window glass, is likely to produce decomposition and cause an explosion, owing to the fact that imperfections in the glass concentrate the rays at certain points. A strong electric discharge, or a flash of lightning, will usually explode dynamite. Dynamite, placed in water, gradually parts with its nitroglycerine, its place in the cartridge being taken by water. Attention is especially drawn to this fact because of the popular impression that dynamite is unaffected by water, an error that has probably arisen from

the fact that it can be used in wet holes or under water. In wet situations, it should be fired soon after preparing the charge. Under no circumstances should it be allowed to remain unexploded for several hours, otherwise the nitroglycerine will leak out and find its way into crevices where it may cause accidents later on. The characteristics given above apply to all those explosives popularly known as dynamite, giant powder, dualin, atlas powder, hercules powder, rendrock, etc.

Gelatin dynamite is an explosive in which the blasting gelatin has been incorporated with a dope to modify its action. For these explosives a stability test is important. For this purpose, repeated freezing and thawing, followed by the test for leakiness, as with ordinary dynamites, and prolonged exposure to a temperature of 90° F., again testing for leakiness, are requisite. Any tendency to leak, under such circumstances, is due to the presence of moisture in the ingredients, and the fault lies entirely with the manufacturer, and not to exposure under unsuitable conditions in transportation or storage. Gelatin dynamite possesses many advantages over the common dynamites, and is rapidly supplanting them in most European countries. It is not, however, as safe a material, being subject to spontaneous explosion, and being untrustworthy in cold weather. Until these disadvantages are overcome, it is not a desirable explosive except in the hands of a man of wide experience and caution.

Harmful Fumes. — The resulting deleterious fumes of the explosion of common powders are carbonic acid (CO_2), carbon monoxide (CO), and nitrogen. The latter is evolved in comparatively small quantities, but its effect is the same as that of carbonic acid — simple asphyxiation. A patient overcome with carbonic acid and nitrogen, if rescued in time, will be speedily resuscitated by an ample supply of pure air. The case is otherwise with carbon monoxide. This is a poison. If carbon monoxide, or the air containing it, is inspired, it gradually replaces the

oxygen, volume for volume, in the red corpuscles of the blood, and death soon occurs. A very small quantity in the air ($\frac{1}{400}$ to $\frac{1}{1000}$) suffices, in a relatively short time, to form a quantity of carbonic-oxide-hæmoglobin. In very partial poisoning, the blood gradually gets rid of it through the respiratory organs. Being a stable compound, it circulates in the blood vessels, but neither gives up oxygen to the tissues, nor takes up oxygen from the lungs, hence, its very poisonous properties. The real cause of death is that the internal respiration is arrested. Its effects are, first, stimulation, and afterwards, paralysis of the nervous system, as shown by the symptons induced, e.g., violent headache, great restlessness, excitement, increased activity of the heart and respiration, salivation, tremors and spasms; later, unconsciousness, weakness and paralysis, labored respiration, diminished heartbeat; and lastly, complete loss of sensibility, cessation of respiration and heartbeat, and death. At first the temperature rises several tenths of a degree, but it soon falls one degree or more. The pulse is also increased at first, but afterwards becomes very feeble though frequent. Where the quantity of carbon monoxide is large (as in the case after a blast in mines where the combustion of the explosive has, from any cause, been imperfect), there is temporary, but pronounced, paralysis of the limbs, followed by violent spasms.

The volitalization of nitroglycerine in small quantities after dynamite explosions causes fumes which produce practically the same effect, when inhaled, as carbon monoxide. The absorption of small amounts of nitroglycerine through the skin, or consumed in eating food with the hands, in case a person has neglected to wash the hands after handling dynamite, causes similar symptoms. Severe and prolonged headaches are characteristic of nitroglycerine poisoning. In unusual cases, headache has been known to persist for three weeks.

The treatment in case of nitroglycerine poisoning con-

sists of the usual procedure in cases of asphyxia. In ad tion to this, it should consist of the use of cold applicati to the head, and of atropine, ergotine or other vaso-mo stimulants, administered sub-cutaneously; also the inha tion of ammonia and carbonate, and aromatic spirits ammonia taken internally.

Fuses. — Safety fuses are essentially slow-burning fu in which the fire of the powder travels along slowly wit the fuse, an average rate being about one foot per l minute. When blasting holes, the fuse should be as lo as the hole is deep, or longer if necessary, in order to sure perfect safety. Fuses should never be less thar feet in length for pops, block holes and shaking holes.

Quick-burning fuses are used in place of electricity accomplish simultaneous firing of a number of holes. Th fuses burn at the rate of about 500 feet per second. order to fire several holes at the same instant, the fu should all be of equal length and attached to a sheet i connector, in one end of which is a disc of powder an perforated wooden plug for the insertion of an ordin safety fuse.

Fuses should be kept perfectly dry. They should preferably stored in canisters. Care should be taken keep them out of contact with oils. They should ne be stored in open coils with caps, powder, or dynamite.

Detonators or Exploders. — For use with high exp sives, detonating caps are essential to impart a suffici initial impulse to develop the full strength of the powd These differ from caps employed for sporting ammuniti in that the heat engendered in exploding the fulminate employed in the latter to ignite the powder, the quality the fulminate used being very low, and fired in cont with the powder. In the case of detonators, however, t fulminate is enclosed in a copper capsule, out of conta with the explosive. The detonation of the fulminate p verizes the end of the capsule, so that the temperatu resulting from it is communicated to the explosive; b

it is the violence of the shock that is relied upon to start the detonation of the high explosive.

The stronger the detonator used, the more powerful will be the detonation of the dynamite or other high explosive. The treble strength should be used in ordinary practice, as it is more economical than the lower grades.

The end of the capsule above the composition is left open to receive the end of the fuse, the fulminate composition being held in place by shellac, collodion, thin copper foil or paper. In electric detonators, a piece of resistance wire is compressed in the composition, the ends being attached to copper wires leading out through a hard plug of sulphur and ground glass which fills the capsule. These wires are wound with cotton insulation. The heating of the short piece of resistance wire to incandescence, due to the passage of the electric current, explodes the fulminate. This is the most reliable form of electric detonator, which, however, requires currents of great intensity, though of low tension, to fire a large number of detonators. For this purpose, powerful electric machines are required. There are also other types of caps. A bridge detonator depends upon electric sparking to fire the composition. This form of detonator is very sensitive, and great care should be taken in its manipulation and coupling.

Making up Cartridges. — In the use of fuse for exploding gunpowder, it is only necessary to see that the end of the fuse is well buried in the charge, no matter whether the powder is poured loose into a dry hole, or made up in cartridge form. When made up into cartridges, the ends of the paper should be securely tied around the fuse, but not so tightly as to constrict it or break the continuity of the powder core. The cartridges may be made by using a long strip of brown paper, folding one end around the end of a cylindrical wooden form, and then spirally winding the paper around the form with the edges well overlapping. Before removing the case, it should be

dipped into melted paraffin, applying several coats. If the hole is very wet, another wrapping in the reverse direction, with a coating of paraffin, will insure the dryness of the charge. After loading and attaching the fuse, it may be immersed up to the fuse in melted paraffin, making sure that it is not appreciably hotter than the melting point of the paraffin, viz., 113° F. This will make a perfectly water-tight cartridge, but it cannot, of course, be rammed into a hole without destroying its waterproof qualities.

Detonators are only employed with high explosives. One end of the cartridge paper is opened, and a hole is made by firm pressure with a hardwood instrument, with a rounded end, no larger in diameter than the cap to be inserted. The hole should be driven to no greater depth than is suitable for the cap, so that the end of the cap will reach the bottom of the hole and leave at least $\frac{1}{8}$ of an inch of the end of the copper capsule projecting above the end of the cartridge. Otherwise, the fuse, coming in contact with the dynamite, may ignite and explode it before detonation can occur, thus greatly reducing the power of the explosive, and producing deleterious fumes from the imperfect combustion of the powder. The ends of the paper of the cartridge are then drawn closely around the fuse and tied as before. The cartridge thus prepared is called the "primer." The same method is pursued in placing the electric detonator, with the difference that it is not objectionable to bury the cap in the dynamite. Under no circumstances, however, must this be done with caps fired by a fuse. It is of the utmost importance, in order to realize the full force of the explosion, that the cap shall fit neatly and perfectly in the hole made for it in the dynamite. An air space, even of a small fraction of an inch below the cap, will serve as a cushion, masking the force of the detonation of the cap, thus reducing the initial violence of the explosive wave imparted to the dynamite upon which directly depends the violence of the explosion which it produces.

The end of the fuse, which is to be inserted into the cap, should be squarely cut off, preferably with a fuse-cutter, such as is supplied by all dealers in explosives. The fuse should then be held vertically with this end uppermost, slipping the cap lightly over it. The cap should not be pressed on the fuse, nor turned on the end of the fuse, as the friction thus generated may explode the cap. The walls of the cap should then be crimped upon the fuse, about $\frac{1}{8}$ of an inch below its upper end, by means of a crimping tool which is combined with a fuse-cutter. No other instrument should ever be used. Under no circumstances, should the cap be fastened to the fuse by biting the cap with the teeth. Serious and fatal accidents have frequently resulted through this form of carelessness.

A lighted candle should never be carried in the hat when making up cartridges, as hot grease of the candle may drop on the caps or powder and cause an explosion. The candle should be placed at least 2 feet to one side. SMOKING SHOULD NEVER BE PERMITTED WHEN HANDLING EXPLOSIVES, MAKING UP CARTRIDGES OR CHARGING HOLES.

Charging Holes with Black Powder. — After removing the sludge, dry the hole with a wisp of hay, or a rag, or cotton waste, fastened to the end of a rod. Then pour in the powder through a copper or tin funnel with a long stem, so that the powder will reach the bottom of the hole without touching its sides above the limit of the charge. If the hole is horizontal, a long scoop may be used, filled with powder, which, when at the end of the hole, is turned around to deposit the charge. For either horizontal holes, or those inclined upwards, the powder may be placed in small paper bags, being closely pressed into the hole. For wet holes, waterproof cartridges must be made as previously explained. The fuse should then be put into place, and in case the hole is filled with powder in paper bags, the fuse should be tied to the last bag. Dry clay should then be pressed over the charge, followed by the ordinary damp clay tamping, pressed firmly for three inches, after which

it may be rammed by tapping the end of the tamping stick with a hammer. In holes one inch in diameter, the charge can not blow out 7 inches of good tamping. With a hole two inches in diameter, 18 inches of tamping are required. A three inch hole requires 20 inches of tamping. These are the lowest permissible limits and an excess should always be used. The amount of the charge has no relation to the length of tamping required. The determining factor is the diameter of the hole.

Charging Holes with Dynamite. — The several cartridges constituting the charge are first inserted, care being taken to have the bore-hole of such a size that they may freely pass to the bottom without binding. It should never be necessary to force them to the bottom. In order that they may be compressed to fill the entire width of the hole, the cartridge paper must be cut lengthwise. This should be done with a copper blade, and not with a steel knife, as the use of the latter is attended with danger. The cartridges should then be firmly compressed with a wooden tamping rod, but they should never be rammed. Firm pressure only is allowable. No steel or iron instrument should ever be used in charging any kind of explosive in a bore-hole. The cartridges should be so well compressed upon each other that no air spaces remain between them. Otherwise, an air cushion will be produced, and if it should not cause a portion of the charge to escape explosion, it would at least prevent perfect detonation, weakening the effect of the explosive. The primer, previously described, is usually inserted last. The cartridge paper should be firmly tied to the fuse above the cap with a string, one end of which should be long enough to admit of lowering the primer into the hole with it. Lowering the primer by the fuse or wires is apt to loosen the cap. An air cushion would thus be formed below it, reducing the power of the explosion. Carelessness in regard to this simple detail is one of the most common causes of waste in the use of dynamite. THE PRIMER SHOULD NEVER BE

COMPRESSED OR RAMMED UPON THE CHARGE. The tamping should then be placed in the hole, using the same clay tamping as required with black powder. Tamping should be absolutely free from gritty particles. The best material is clay, damp enough to merely retain its form when compressed into a ball in the hand. Pellets of this clay should be dropped into the hole and very lightly compressed with a wooden tamping rod until about six inches of the hole above the charge has been filled. From this point to the top, the tamping may be more firmly compressed, but it should never be rammed.

Firing the Charge. — The free end of the fuse should be kept out of water and no two fuses should cross each other. A slit should be cut one-half an inch long in the end, to sufficiently expose the core for prompt lighting. Wicking, or other material soaked in oil, should never be attached to the end of the fuse for igniting it, but if desired, dry paper may be twisted upon the end. If properly slit, and turned sideways, so as to expose the core without shattering out the powder, the fuse can be readily lighted with a candle flame.

For the electric firing of black powder, low power fulminating caps are employed. It is erroneously stated by many that the power of black powder is increased by the use of the fulminating cap, i.e., that it is detonated. As a matter of fact there is no advantage in the use of strong detonators with common black powder.

In firing by electricity (battery), the ends of the copper wires, attached to the detonator, should be twisted tightly upon the ends of the heavily insulated "leading wires." The ends should be bent over, forming a hook, so that the detonator wires cannot, for any reason, become detached. The ends of the wires should be scraped bright, so as to insure ample contact between clean surfaces. Where more than one hole is to be fired at the same time, separate connecting wires should be employed to connect the whole series of charges. Care should be taken not to allow any

bare portions of one wire, or even the insulated part of a wire, to touch another wire, nor to come in contact with damp earth or rock. The leading wires should never be twisted together, nor carried to the working face in contact with each other. They should not be in contact with pipes or other metallic objects, nor should they lie in water. Disregard of these precautions will often result in "short-circuiting" or grounding the current, causing either failure to explode the charges at all, or a misfire in some of the holes. The hands of the operator, while connecting the wires, and especially while connecting the leading wires to the battery, should be perfectly dry.

The standard blasting battery of to-day is a dynamo-electric machine, which is not affected by moderate dampness, and which is always ready for use. This consists of an electro-magnet, between the poles of which rotates an armature, developing the current precisely as in an ordinary dynamo. The armature is driven by a rack and pinion, the current thus generated being rectified by a commutator. The armature is short-circuited until the rack, in descending, breaks the short circuit. The current then passes into the firing circuit through the terminals or binding posts to which the leading wires are attached. Machines which are operated by a crank are more susceptible to accidents from a premature discharge than the so-called "pull up" batteries, worked by a rack and pinion. A machine is rated at the full number of detonators which it will fire under favorable conditions. To insure freedom from misfires, it should never be worked up to its maximum rated capacity. Nothing other than standard firing machines should be used in firing charges where electricity is employed.

Electrical firing is preferable to firing with fuse, as the danger of accidents, caused by premature or delayed firing, are diminished. It also has the advantage that the charge can be fired at any desired distance at a certain specified time. The chances of misfires are also lessened.

It gives the operator an opportunity to station himself at a safe distance from the blast.

Where fuses are employed, they should be in good condition and free from defects of any kind. One man should never be allowed to fire more than five holes at one time.

FIG. 104
Portable steel refuge house for safety of workmen during blasting operations.
Courtesy United States Steel Corporation.

If necessary to fire more at one time, he should receive assistance.

BEFORE FIRING, ALL PERSONS IN ALL DIRECTIONS OR APPROACHES SHOULD BE GIVEN SUFFICIENT WARNING TO ENABLE THEM TO GAIN A POSITION OF SAFETY. When two gangs of miners are drifting toward each other, one gang should always notify the other before blasting. On surface blasts, in connection with highway construction, etc., special

care should be taken to warn the public, especially any children that may be playing in the vicinity.

Misfires. — Holes which have misfired are dangerous. When the firing is done by electricity, no one should be allowed to approach the hole for at least half an hour. When firing by fuse, the hole should not be approached for at least two hours. It is then best to loosen the fuse, if possible, retreat quickly, and again wait for fifteen minutes. If no explosion occurs, then proceed to withdraw the tamping with a copper or wooden spoon. NEVER USE IRON OR STEEL INSTRUMENTS FOR THIS PURPOSE. In the case of high explosives, or of black powder which has been primed with a cap or detonator, remove the tamping to within about 3 inches of the charge, BUT NO CLOSER. Then recharge above this with a large charge of dynamite, and detonate it in the ordinary way. If black powder and fuse have been used, withdraw all the tamping, recharge above the old charge, and then fire. If dynamite is available, it is safer to explode such a missed hole with a dynamite primer, which should not be compressed before firing. In all other instances, two kinds of explosives should never be used in the same hole.

Thawing Dynamite.— Dynamite should never be used while in a frozen or partly frozen condition. It should never be bent, cut, or compressed in any way while in this state. Frozen dynamite should be carefully thawed before use. It should never be thawed by direct heat from a fire, stove, candle, matches or any other open light, nor should it be placed in a tin can or pail over a fire, or thawed in hot water. It should not be exposed to the direct rays of the sun, especially when transmitted through window glass.

Dynamite should be thawed in a room heated by steam or hot water pipes, in which case the explosive should never be laid on the pipes. It may be thawed by placing it in a vessel surrounded by warm water. The proper temperature of the water is 125° F., which is approximately the tempera-

ture at which the bare hand can just be held in the water without pain. The water should be separately heated and poured into the water space in the thawer. The thawer should never be heated over a stove or some other source of heat. All seams in the thawer should be absolutely smooth, so as to leave no crevices for the lodgment of dirt or nitroglycerine. There should be a water space of at least 2 inches between the inner vessel containing the dynamite and the outer vessel containing the water. Electric heaters for thawing dynamite are known to be less efficient and less safe than low pressure steam or hot water coils.

In using any form of thawer, the cartridges should be free from sawdust. The vessel or tubes holding them should be kept very clean. The only way to make sure of keeping the thawer free from accumulations of nitroglycerine is to wash it out after each thawing with a strong solution of carbonate of soda (sal-soda or washing soda), which is best applied warm.

Dynamite is never properly thawed if it feels lumpy at any part of the cartridge. It should be uniformly pliable throughout. Its use when but partially thawed is attended with danger in loading, and its detonation will be imperfect, with the consequent disadvantages of yielding a less powerful effect and giving off noxious fumes.

Dynamite should never be thawed underground. In cold weather it may be sent underground in non-conducting cases or packages to prevent it from freezing after being thawed on the surface.

Adaptation of Explosives. — Adaptation of explosives to the kind of work to be executed is of the utmost importance. Dynamites are not suitable for quarrying, except where rubble is being obtained. Only the lowest power (40 %) should then be used. Black powder serves best for quarrying, bank blasting, etc., although joveite of the lowest power develops its explosive effect with sufficient slowness to be adapted to such uses. A slow acting powder is also essential for certain ores which contain galena and

other minerals, which may be too highly pulverized by high explosives. High explosives pulverize and shatter; black powder fractures. The higher the power of the dynamite, the larger is the sphere of pulverization. For railroad work, chambering, and for "dead work" in mines, such as shaft sinking, tunnel driving, etc., it is advantageous to use the higher grade of powders, such as 60% and 75% dynamites, or their equivalents in other forms of high explosives.

Hints on Blasting. — There are few operations in mining or quarrying where a workman can display a higher degree of skill, and effect larger economy, than in the proper placing of bore-holes, and in the proper adaptation and adjustment of the charges to the work at hand.

For the most part, efficient work in blasting is a matter of experience and good judgment. This cannot be taught in books, but there are a few general fundamental rules, and in proportion as these are understood and applied, blasting will be conducted with a greater system of economy and safety. Unsystematic effort is always wasteful and costly. System implies the recognition of definite principles according to which the work is laid out and prosecuted.

A few points of prime importance, which should be observed, are the following:

1. The strength and quantity of the explosive should be properly proportioned to the cohesive strength or resistance of the rock.

2. The "burden," or line of least resistance (i.e., the shortest line that can be drawn from the charge in the bore-hole to the outer free face of the rock), should bear a proper relation to the strength of the explosive and to the resistance of the rock.

3. If the working face of the rock is so blasted as to leave two or more free faces, for future blasts, instead of one, the power required to overcome the resistance of the rock will be reduced, and explosives should be economized.

4. A seam or fissure is a valuable aid in blasting, if the hole is so located that advantage of this weakness may be taken. On the other hand, the power of the explosive may be expended along such a seam without doing useful work, if the hole is improperly located.

5. Breaking to regular benches and faces is more economical than irregular breaking, because the condition of the rock can be more carefully observed,

admitting a more intelligent placing of subsequent bore-holes. In addition, it facilitates the setting up of machine drills. It is also more convenient for work by hand drilling, keeping the face in better condition for a complete and economical extraction of ore or rock.

6. Simultaneous firing is more economical, in most cases, than firing singly or in series, for the reason that the adjacent charges assist each other, reducing the amount of explosive required, as well as the total length of holes to be drilled for any given volume of rock.

7. Careful charging, so as to secure as highly compacted a charge as possible, greatly increases the efficiency of the explosive.

8. A well prepared primer, in the case of high explosives, is the key to a successful detonation of the charge, upon which, other things being equal, its efficiency depends.

9. The efficiency of all explosives is dependent, to a considerable extent, upon the kind, length, and degree of compactness of the tamping.

10. The object of blasting in mines and quarries, and in construction operations, is to rupture the rock so that it may be removed, not to hurl it to a distance, i.e., not to secure what military engineers call a "ballistic" effect. Hence, only enough explosive should be used to accomplish the former. When fragments are thrown more than a few feet by a blast, it is generally an evidence that the proper relation did not exist between the charge and the burden, or that too large a charge was used for the length of the line of least resistance.

Storage.—Local conditions should determine the type of structure to be built for an explosives magazine. In general, the lighter the construction the better. Thus, in event of an explosion, the building will be completely disintegrated, no pieces being thrown to a distance. This reduces the radius of danger to a minimum. In case of danger from fire or robbers, a heavier construction will be required.

Magazines should be located at a safe distance from dwellings, factories, public buildings, highways, and railways. The following table gives the minimum distances between barricaded magazines and railways, highways, or inhabited dwellings and buildings. For any magazine, not protected by a substantial artificial or natural barricade, the distances should be doubled.

Quantity of Explosives Stored	Proposed Distance		Quantity of Explosives Stored	Proposed Distance	
	Inhabited Building	Public Railway		Inhabited Building	Public Railway
Pounds	*Feet*	*Feet*	*Pounds*	*Feet*	*Feet*
50	120	70	10,000	890	535
100	180	110	20,000	1,055	635
200	260	155	30,000	1,205	725
300	320	190	40,000	1,340	805
400	360	215	50,000	1,460	875
500	400	240	60,000	1,565	940
600	430	260	70,000	1,655	995
700	460	275	80,000	1,730	1,040
800	490	295	90,000	1,790	1,075
900	510	305	100,000	1,835	1,100
1,000	530	320	200,000	2,095	1,255
1,500	600	360	300,000	2,335	1,400
2,000	650	390	400,000	2,555	1,535
3,000	710	425	500,000	2,755	1,655
4,000	750	450	600,000	2,935	1,760
5,000	780	470	700,000	3,095	1,855
6,000	805	485	800,000	3,235	1,940
7,000	830	500	900,000	3,355	2,015
8,000	850	510	1,000,000	3,455	2,075
9,000	870	520			

It is important to select a site with a natural barricade such as surrounding hills or knolls, otherwise an artificial barricade of earthwork mounds should be constructed, if the country is inhabited thereabout. It is, however, essential to select a site that will admit of good drainage. It is better to erect the magazine on sandy soil, than on rocky ground or solid rock, for, in the event of an explosion, the effect of the explosion waves will be greatly diminished and far less reaching than if the magazine were constructed on solid rock. When the magazine is partly or wholly below the surface of the ground, the barricades are more effective, but it is then sometimes impossible to secure good drainage, which is of prime importance.

Under no circumstances should explosives be stored in caves, tunnels, earth or stone-covered vaults, or in log structures. These structures will hold dampness, and any

dampness is sure to render the explosives dangerous for subsequent use.

A suitable building is one made of common weather-boarding on a framework of $2'' \times 4''$ stock, with a tight flooring of tongued and grooved boards, blind nailed, with walls and ceiling sealed with the same material. The roof should be protected with tarred paper. Where there is danger of fire the lightest steel shingles should be used on the roof and outer walls. The door should be heavy, and should open outward in all cases. Openings for ventilation should be provided around the bottom, protected by wire screens against the entrance of vermin, being so constructed that water cannot enter. A hooded ventilating pipe should extend from the ceiling through the roof. Where danger of explosion from the bullets of firearms is at all likely, safety may be insured by constructing a wainscoting inside the magazine, leaving a space of six inches between it and the wall, made sufficiently tight to hold fine dry sand, with which the interspace should be closely filled. This will be sufficient to stop any bullets from entering the magazine. The structure should be covered with a network of wires, which should be grounded at several places. The earth plate should be large, and placed either in water or permanently moist soil. The magazine should be located as far as possible from buildings, railroads, working places, and highways, as is consistent with existing conditions. It should be plainly marked upon all sides, and upon the door, with large conspicuous "DANGER — HIGH EXPLOSIVES" signs. A weatherproof placard of instructions and rules should be placed upon the door.

Before making any repairs or alterations in a magazine, all explosives should be carefully removed to a safe place. The interior of the building should be thoroughly washed with a strong solution of carbonate of soda. All tools used in making repairs should be of wood or brass. Many explosions have resulted in driving nails into the floors of

old magazines, or buildings that have been used in the manufacture of explosives. The floors of magazines should be kept free from dirt, grit and other similar material.

No artificial heat of any kind for thawing, or other purposes, should be introduced in a magazine. When thawing is necessary, the explosives desired for immediate use should be taken away from the magazine, and thawed in a suitable thaw-house above ground.

When a new consignment of explosives is received, it should be stored in the magazine in such a way that the oldest explosives will be used first.

For the storage of gunpowder, the magazine should be fitted up with racks, so arranged that the kegs may lie in a slightly inclined position. Dynamite should be stored in tiers, box on box, with battens between the successive layers of boxes to insure good ventilation and to lessen the danger from friction.

Gunpowder in unopened kegs, dynamite in unopened boxes, and fuse securely boxed, may be stored in the same magazine, but no caps or detonators, or loose coils of fuse, should ever be stored in the same magazine or in any other place with gunpowder and high explosives.

The magazine should be kept scrupulously clean. All loose leaves, dead grass, rubbish or other combustible material should be cleaned up in the vicinity of the magazine, on account of the danger from fire. No fire should be permitted near the building. Men with nails exposed on the soles or heels of their boots should not be allowed to enter or work in any magazine. SMOKING IN THE VICINITY OF EXPLOSIVES SHOULD NOT BE ALLOWED.

Gunpowder kegs should be rolled over every two or three weeks to prevent caking. Cases of dynamite should be turned over once every two weeks in order to keep it in a perfectly homogeneous condition. This is not necessary, however, if the dynamite remains frozen.

No keg of gunpowder, or box of dynamite or other explosives should ever be opened in a magazine. The

kegs or canisters of gunpowder should always be kept closed, after removing the amount needed for immediate use. In the case of dynamite, it is best to unpack the total contents of the box at once, wipe off the sawdust, lay the cartridges upon their sides on planed board shelves, and then carefully remove all fragments of the original boxes and sawdust, which should be burned in the open. Such sawdust usually contains more or less nitroglycerine, unless the dynamite is in an unusually perfect condition. An oily stain on the cases indicates that nitroglycerine has leaked from the cartridges. The shelves in the building where the cases are opened should be frequently inspected. If an oily stain is observed, no matter how small, it should be thoroughly washed with a solution of carbonate of soda. The floor of the magazine should also be occasionally washed with this solution.

Unopened boxes of dynamite should never be taken into a mine, since the removal of sawdust and fragments of the boxes is not so easily accomplished as it is from buildings above ground. Only dynamite cartridges which have been wiped free from sawdust and placed in clean boxes should be sent below.

It is always advisable, upon receiving a fresh consignment of explosives, to test the quality and inspect the explosives to make sure that the material is in good condition. The opening of one box or keg out of every ten will usually suffice to detect any deficiency. If not in good condition, the manufacturers should be notified at once. If faulty, the explosives should not be returned, for their shipment under such circumstances, especially in the case of nitroglycerine powders, is dangerous. They should be destroyed. For this purpose, select a sufficiently isolated situation. Lay the dynamite cartridges on the ground, end to end, or in the form of a very open spiral. Pour paraffin oil over the entire train, or if this is not available, use kerosene. Ignite one end of the train with an ordinary fuse. Never use a cap for destroying dynamite. The dy-

namite will burn quietly and safely when ignited with a fuse. It may also be destroyed by saturating it with yellow ammonium sulphide.

Transportation. — In the transportation of explosives by ordinary road vehicles the points to observe are: First, the vehicle should be inspected to make sure that it is in good condition, and that it contains no projecting metal parts or nails inside the bed or sides. Second, that the cases containing the explosive are securely packed to prevent movement against or upon each other, or upon the sides and bottom of the bed. A small quantity of clean straw on the bottom of the bed and between cases is a necessary precaution, especially when the explosive is to be hauled over a rough road. After unloading, the straw should be gathered and burned at a safe distance from the explosives. Third, the cases should, in damp weather, be covered with waterproof canvas or tarpaulin. In warm weather, a white canvas cover over the vehicle is important to prevent undue heating from the sun. Fourth, the vehicle should always be provided with a conspicuous "DANGER, HIGH EXPLOSIVES" flag to give necessary warning to everyone. Fifth, where possible, passage through a town, or the more densely populated sections of a town or settlement, should be avoided. Sixth, when necessary to pass through a town it should be quickly done, without making stops for any purpose. These or similar precautions are made obligatory by law in most countries.

The following extracts from the "Blasting Regulations" of the Municipal Explosive Commission of New York illustrate important precautions which should be observed:

"Sec. 141. It shall be unlawful for any person to carry or transport explosives through the streets, avenues or highways of the City of New York except in a wagon for which a permit shall have been issued by the Fire Commissioner.

"Sec. 142. Each wagon used for the transportation of explosives shall have strong running gear and a wholly enclosed wooden body mounted on suitable springs. The bed of the wagon shall be of two thicknesses of sound boards,

free from knots, tongued and grooved, not to exceed three inches in width, so laid as to break joints, and to be blind nailed, with the top surfaces planed smooth. The only entrance to the wagon shall be by means of a door at the rear, which door shall be kept locked except when the wagon is being loaded or unloaded.

"Sec. 143. Each wagon carrying explosives shall be painted vermilion, and shall have painted on its sides and back, in easily legible white letters at least twelve inches high, the word 'EXPLOSIVES,' and in smaller letters and figures the name of the owner and the number of the permit.

"Sec. 144. Each wagon carrying explosives shall display upon an erect pole on the front end thereof, and at such height that it may be visible from all directions, a red flag with the word 'DANGER' painted, stamped or sewn thereon in white letters. Each flag shall be at least 18 by 30 inches in size, and the letters thereon shall be at least 12 inches in height.

"Sec. 145. Each wagon carrying explosives shall be drawn by a horse or horses amply able to draw the load. No unnecessary stops shall be made in transit, and while the wagon is at a standstill a person holding a certificate of fitness shall be continuously in charge thereof.

"Sec. 146. Each wagon carrying explosives shall be continuously in charge of two competent persons, each holding a certificate of fitness as a handler of explosives, and no other person shall be allowed in or upon such wagon.

"Sec. 150. It shall be unlawful for any person to place or carry in or upon a wagon containing explosives any exploders, detonators, blasting caps, or other explosive material, or to carry in or upon such wagon any matches or any mechanical device for producing spark or flame.

"Sec. 151. No wagon containing explosives shall be driven for more than one city block along any street, avenue or highway within the City of New York over which there is an elevated railroad or under which there is a tunnel or subway for the transportation of passengers or freight, nor through a crowded street, avenue or highway.

"Sec. 152. It shall be unlawful for any person to carry or transport in or upon a wagon within the City of New York any explosives in excess of 1,000 pounds."

For transportation of small lots of explosives about mines and quarries, they may be sent in tramcars, or lowered in skips, buckets or cages. Warning should always be given of the approach of such a cargo. When feasible, this work should be done between "shifts," so as to expose as few men as possible to danger. Only experienced and trustworthy men should be detailed for service of this kind. The carrying of a case on the shoulder is often the safest mode of conveyance of a small quantity. UNDER NO CIRCUMSTANCES, SHOULD EXPLOSIVES BE CARRIED UP OR DOWN LADDERS, except in very small quantities to working places for immediate use.

The regulations governing the transportation by railroads vary with different companies, being more or less limited by legislation. As an example of voluntary regulations by a railroad company may be cited those which went into effect on September 25, 1899, on the Pennsylvania Railroad, a line which handles perhaps a larger quantity of explosive materials than any other in the world, and which has consequently had the most extensive experience. In order to show the degree of care which this corporation finds it advisable to take as a part of its business policy, the order is now quoted nearly in full:

1. Explosives will be received for transportation over the above lines (P. R. R., P. W. & B. R. R., N. C. S. Ry., and W. J. & S. R. R.,) branches, and immediate connections under their control, only under the following regulations.

2. The safe transportation of explosives is believed to be largely influenced by the manner in which the explosives are packed for shipment. Furthermore, information in regard to the kind of explosive that is being transported is essential, in order that the railroad employees may not ignorantly do anything to incur danger.

3. **Classification.** For transportation purposes, all explosives will be divided into the following groups: Common Black Powder, High Explosives, Smokeless Powders, Fulminates, Ammunition, and Fireworks.

4. **Common Black Powder.** When these explosives are packed in packages containing less than 20 lbs. each, these packages must be enclosed in a wooden box in such a way that the filling hole is up, and the boxes when filled must not weigh over 100 lbs. Each box must be stenciled on top — "Common Black Powder." The prismatic powders must be packed in tight tin boxes, which must be enclosed in a wooden box. The whole package must not weigh over 100 lbs. and must be stenciled as above. When 20 lbs. or over of sporting, rifle or blasting powder are contained in one package, this package is preferably a wooden keg or cask. If iron kegs or casks are used, it is desired that they be enclosed in a wooden jacket, but naked iron or steel kegs or casks will be received. These naked kegs or casks must be so well made, and the filling holes so well secured, that when filled with the same weight of sand as they are designed to carry of powder, and dropped in any manner a distance of four feet on a rail, they will not be ruptured and none of the sand will escape. These explosives will not be received in packages over 100 lbs. each except for export, when larger packages will be received. Each package must be stenciled as above.

5. **High Explosives.** Under high explosives are embraced all explosives more powerful than ordinary black powder, excepting smokeless powders and fulminates. These include those known under the various trade names of Acme, Ætna, Atlas, Climax, Commercial, Dittmar, Forcite, Fumeless, Giant, Hecla, Hercules, Joveite, Big Chief, Judson, Samson, Rend-Rock, Rack-a-rock, etc. The following regulations will apply to explosives of this group:

6. No explosive of this group will be received for shipment in the liquid or bulk form. Explosives like Rack-a-rock, one constituent of which is liquid, will be received, provided the liquid itself is not explosive, and provided the liquid is not packed in the same boxes with the other constituent. High explosives must be made up into cartridges, and the cartridges must be so arranged in the boxes that, when the boxes are loaded top side up, all cartridges will lie on their sides, and never on their ends. Each package must be plainly stenciled, "HIGH EXPLOSIVES — DANGEROUS," on top and one side or ends. Explosives which consist of a liquid, combined or mixed with an absorbent material, must have the ingredients uniformly mixed, and the liquid constituent thoroughly absorbed. The amount of the liquid must be such that the temperature of the hottest summer day will not occasion leakage. The shells or cases consisting of paper or other material used in making the cartridges must be of such material, or so treated, that the liquid constituent of the explosive will under no circumstances be absorbed by the case or shell.

Sections 7 to 10 refer to smokeless powders which will not be discussed here, they being solely employed for military and sporting purposes.

11. **Fulminates.** Under fulminates, for the present, is included only fulminate of mercury in bulk form — that is, not made up into percussion caps, detonators, blasting caps or exploders. Fulminate of mercury in bulk must contain, when packed, not less than 25% of water, and must, in this wet condition, be placed in a 12 oz. duck bag and securely tied. This duck bag must then be placed in a rubber bag, which rubber bag must then be filled with water and securely tied. The rubber bag and contents must then be placed in a tight cask, the empty space around the bag filled with sawdust, the cask filled with water and then bunged and sealed. Each cask must be stenciled "Fulminate."

12. Under ammunition are embraced cartridges to be used in sporting or fowling pieces, etc., . . . Also under ammunition are embraced detonators, blasting caps, percussion caps, fulminators, exploders, track caps, fog signals, and other articles of like nature. The following regulations apply to ammunition.

13. Cartridges or ammunition must be packed in pasteboard or other boxes and these pasteboard or other boxes must be again packed in strong wooden boxes, not too large or heavy to be readily handled by one person. Each package or case of ammunition must be plainly stenciled "Ammunition — Handle Carefully." . . .

Sections 14 and 15 apply to fireworks.

16. **Loading Explosives Together.** Black powder, high explosives, and smokeless powder of all kinds may be loaded together in the same car. Fulminate, ammunition, and fireworks must never be loaded with each other, nor in the same car with black powder, high explosives or smokeless powder. . . .

17. **Shipping Days.** Common black powder, high explosives, smokeless powders, and fulminates, in car load lots, will be received (when laws or ordinances permit) on any day except Saturday, and in less than car load lots on

Mondays and Thursdays of each week. Ammunition and fireworks will be received at any time, and may be loaded with other freight, except as provided in Section 16, but should, if possible, be loaded so as to avoid transfer at stations.

Then follow regulations as to shippers' certificates, and certificates of inspection of the car containing explosives, etc.

23. **Selection and Preparation of Cars.** Only box cars, which have been specially selected and specially inspected, will be used in the transportation of the first four groups of explosives, and they must be in first class condition in every respect, both inside and outside. The following points must be carefully looked after: The car must in no case have loose boards or cracks in the roof or sides, and the doors must shut so closely that no sparks can get in at the joints. When these explosives are loaded in car loads, the doors must be stripped, except when the cars are equipped with Wagner doors, which must not be stripped. The journal boxes and trucks must be examined, and so cared for as to reduce to a minimum the probability of hot-boxes or other failure, requiring the car to be set off before reaching its destination. The car must be carefully swept before it is loaded, and a careful inspection made of the inside. Holes in the floor or lining must be repaired, and special care taken to see that there are no projecting nails or bolts, or pieces of metal which may work loose and produce holes in packages of explosives during transit. Short pieces of hard wood, two inch plank, must be spiked to the floor over king-bolts to prevent the possibility of their wearing through the floor and into the packages of explosives.

24. Agents, and car inspectors at junction points, must refuse to receive from connecting lines cars loaded with these explosives, unless the requirements of section 23 have been complied with.

25. **Handling of Explosives.** In handling packages of explosives at stations and in cars, the greatest care must be taken to prevent their falling or receiving shocks in any way, and they must not be thrown or dropped, but must, as far as practicable, be passed from hand to hand, or carried by one or more persons, and must not be rolled on the platform or car floor, unless they are so heavy that this cannot be avoided. The agent must choose careful men to handle explosives, must see that the platform and feet of the men are as free as possible from grit, and must take all possible precautions against fire. No unauthorized person shall have access to the explosives at any time while they are on the property of the Company. Should any packages of high explosives, when offered for shipment, show outward signs of any oily stain, or other indication that absorption of the liquid part of the explosive in the absorbent material is not perfect, or that the amount of the liquid part is greater than the absorbent can carry, *the packages must be refused in every instance, and must not be allowed to remain on the property of the Company.*

26. All the articles enumerated in Section 12, under the heading of Ammunition, also fireworks and friction matches, or other articles of like nature, must under no circumstances be loaded in the same car with the other kinds of explosives provided for in this circular; nor when unloaded be put near those explosives in the freight station.

27. **Loading in Car.** When explosives are packed in boxes, the boxes must

be so loaded in the cars that they will lie flat, top side uppermost. They must never be loaded on their sides or ends. When explosives are packed in round kegs containing from 20 to 100 lbs. they must be loaded on their sides in rows across the car. Larger casks, barrels or drums may be loaded on their sides or ends as will best suit conditions. Whatever kind or form of packages, it is essential that after they are loaded *they shall be so stayed that they cannot change position under the ordinary shocks of transportation.* Especially must care be taken that they cannot fall to the floor or have anything fall on them during transit.

Section 28 gives instructions as to the marking of cars to indicate their dangerous contents, and Section 29 allows safety fuse, if properly boxed, to be loaded with other explosives.

30. **Handling Car Containing Explosives.** Every person handling explosives in car load lots or less must exercise the greatest care to prevent accidents. A car containing explosives must be hauled as near the middle of a train as possible, and must not be placed next to a car loaded with oil or other inflammable material. The locomotive must remain attached to the car or to the draft containing a car of explosives in handling it to and from a siding, if possible. When this cannot be done, a rope or pole must be used, but a flying switch must not be made with a car containing explosives. Other cars must not be allowed to strike a car loaded with explosives, and such a car must be so placed in a yard, or at a station, that it will be subject to as little handling as possible, and that it will be exposed to as little danger from fire as possible. At every point at which a train stops, the trainman in charge must make a special examination of a car containing explosives, and must carefully examine the journal boxes with a view to locating or preventing hot-boxes on these or adjacent cars. If it should be necessary to cut off, short of its destination, any car containing explosives, the conductor must advise the agent at the station where the car is cut off, and must also advise his superintendent from the first telegraph office. The agent at the point at which the car is cut off must use every possible precaution to prevent accident while the car is under his control.

31. **In Case of a Wreck.** In case of a wreck involving a car containing explosives, the first and most important precaution is to prevent a fire. Although most of the group of high explosives will quietly burn in small amounts and without causing a disastrous explosion, yet it must be remembered that it is the characteristic of most explosives to burn, and consequently everything possible must be done to keep fire away.[1]

Before beginning to clear a wreck in which a car containing explosives is involved, all unbroken packages should, if possible, be removed to a place of safety, and as much of the broken packages as possible gathered up and likewise removed. Furthermore, it should be borne in mind that " high explosives"

[1] The regulations should have called attention to the fact that most explosives in bulk, after burning a short time, become heated thereby to their exploding temperature, and then explode with violence.

are readily fired by a blow, except when they are wet, by the spark produced when two pieces of metal, or a piece of metal and a stone, come together violently. In clearing a wreck, therefore, care must be taken not to strike fire with the tools; and in using the crane or locomotive to tear the wreckage in pieces, the possibility of producing sparks must be considered. With such explosives as "common black powder," "smokeless powders," and "fulminates," thorough wetting with water practically removes all danger of explosion by fire, spark or blow;[1] but with the "high explosives" wetting does not make them safer either from fire, spark or blow. In case "fulminate" has been scattered by a wreck, the ground involved must, after the wreck has been cleared, be saturated with oil and fired. If this is not done, when the ground and fulminate get dry, small explosions will constantly occur whenever the mixed material is trodden on or struck with a blow.

The following rules, concerning the methods of handling and using explosives, have been prepared in a suitable condition to form the contents of a small pocket book of rules which should be issued by every company to all the men in their employ engaged in handling or using explosives. Simple short rules, such as these, will go a long way toward fixing in the minds of workmen the dangers to which they are exposed when handling explosives.

RULES FOR EXPLOSIVES

1. No employee shall be allowed to touch or handle explosives of any kind except those duly authorized to do so.
2. Use great care in handling explosives at all times. Most accidents happen from carelessness.
3. Never allow an inexperienced man to handle or use explosives.
4. Never open a box of dynamite, or a keg of gunpowder, in a magazine.
5. Never open packages of explosives with anything other than a wooden chisel and mallet, or other wooden tool. Never use a nail, wire, iron chisel, or other sharp metal or stone instrument to open the box or keg.
6. There are two safe ways to thaw dynamite; viz., in a room heated by steam or hot water pipes, in which case the explosive must never be laid on or near the pipes; and in a vessel surrounded by warm water previously heated. Dynamite, gunpowder, caps, and other explosives, must never be exposed to the direct heat of a fire, candle, stove, gas-jet or any other open light.
7. Never store caps, or fuse in open coils, with dynamite or gunpowder in a magazine, nor together in any other place.
8. Never store caps and fuses together.
9. Never carry caps and cartridges in the same hand.
10. Never carry a box of dynamite, nor more than several cartridges, up or down a ladder, and even then be sure that none of the cartridges can possibly fall.

[1] Fulminates are sensitive to friction even when wet.

11. Never crimp a cap upon a fuse with the teeth. Use a crimping tool, and carefully perform the operation.

12. Never carry loose caps in your pockets.

13. Never carry dynamite cartridges about in your pockets, boots or blouse, in an attempt to thaw them.

14. Never leave cartridges, or parts of cartridges, lying about under any circumstances.

15. Never toss or throw cartridges anywhere, nor toward anyone.

16. Before firing, always give sufficient warning to everyone soon enough to enable them to get out of danger.

17. Never rub a cartridge between the hands to complete thawing.

18. Never use a frozen, nor even a partly frozen cartridge, until it has been thoroughly thawed.

19. Never reheat water which has been used in a dynamite thawer.

20. Never use a metal rod (other than copper) to force or tamp a cartridge into a hole. Always use either a wooden or copper tamping rod. Many accidents have resulted from the use of an iron or steel bar, or piece of drill steel, in loading holes.

21. Never try to force a cartridge through too small a hole.

22. Never attempt to deepen or redrill a missed hole. Remove the tamping to within three inches of the charge, recharge above this tamping and then fire. Always use either a copper or wooden spoon to remove the tamping.

23. Never drill into a face where a hole has misfired until the tamping has been partly removed and the hole recharged and fired as above.

24. Never return to relight a fuse, if the charge fails to go off, until having waited at least one hour.

25. Never use an iron candlestick, nail, wire, knife, or any other metal instrument, for making a hole in the end of a stick of dynamite for the reception of the cap. Use a round nosed hardwood tool.

26. After shaking a hole, allow enough time for the hole to thoroughly cool before a charge is placed in it.

27. Never smoke while loading holes, making up cartridges, or when near any explosives.

28. Never carry a lighted candle in the hat when making up cartridges. Hot grease from the candle may drop on the caps or powder, causing an explosion. Place the candle two or three feet to one side.

29. Never attempt to hasten an explosion with too short a fuse.

30. Fuse should be at least 2 feet long for pops, block-holes, and shaking holes. When blasting holes, the fuse should be as long as the hole is deep, or long enough to insure perfect safety.

31. One man must not fire more than 5 holes at one time. If necessary to fire more, get assistance.

32. See that all approaches to working places are safely guarded until the blasting is over. Other gangs working nearby should be notified, stating the number of holes to be fired.

33. Where two gangs of miners are drifting toward each other, one gang must always notify the other before blasting.

34. Before blasting, have a definite understanding with your partner as to who is to return to relight the fuse after giving a warning.

35. Never use two kinds of explosives in the same hole.

36. Never attempt to draw a wire from an electric cap or detonator.

37. Never try to destroy a cap by striking it with anything.

38. Never step on a cap or cartridge.

39. Never prick the composition of a cap with a pin, nail, or any other instrument.

40. Never take an unopened box of dynamite into a mine or tunnel.

41. Keep dynamite and powder dry. Never allow it to become exposed to dampness.

42. Always fire cartridges soon after charging wet holes, to prevent the nitroglycerine from leaking into cracks or crevices where it may be accidentally exploded later on.

43. See that gunpowder does not lodge in any seams where it may later become accidentally exploded.

44. Never attempt "trail blasting" with gunpowder, i.e., scattering a trail of powder from the charge to a point where it is to be ignited.

45. On surface blasts, in connection with highway excavation or construction work, take particular care to see that the charges are well covered with logs chained together, with a covering, in addition, of heavy rope matting or matted iron wire, etc. Be sure to give sufficient warning in all directions. See that there are no children playing nearby.

46. Use all possible care in transporting and handling explosives.

47. Inspect all fresh consignments of explosives. Make the proper tests to be sure that they are not of inferior quality.

CHAPTER XXII

MISCELLANEOUS

Eye Protection. — The eye is the most valuable exposed organ of the body. The preservation of vision is all important to everyone. With the loss of vision vanishes the workingman's means of support for himself and his family. He then becomes an object of charity. Thousands of eyes are each year rendered sightless through negligence on the part of both employers and employees. Workmen are generally ignorant of the consequences which are likely to result in the failure to wear safety goggles in performing operations where the eyes are exposed to imminent danger. The process of educating and training workmen to wear goggles, where the eyes should be protected, should be undertaken with vigor. Employers should provide their workmen with individual pairs of safety goggles which are suitable for the work at hand. Goggles should not be interchanged among workmen on account of the danger of spreading disease and infection. Workmen should be required to wear goggles during operations in which the eyes are exposed to danger. This rule should be strictly enforced under penalty of discharge. Discipline may be necessary at the start as a warning to others.

Workmen frequently argue that safety goggles are constructed of glass containing imperfections which may ruin their eyesight. This is true with inferior makes of safety goggles. Nevertheless, the market offers several reliable makes of various types which are of excellent quality and workmanship, and which, at the same time, are comparatively cheap. Workmen also often complain that goggles are uncomfortable. This is mostly due to the new

experience and to the imagination. After the goggles have been worn a few days, the workman becomes thoroughly accustomed to them. He is then barely con-

FIG. 105
Safety goggles with side protectors.
Courtesy Julius King Optical Co.

scious that he is wearing them. The best makes of safety goggles should be selected in fairness to the workmen who are required to wear them.

FIG. 106
Goggles broken by large chip of steel shown at left of figure. The eye of the workman, who was wearing the goggles at the time of the accident, escaped injury.
Courtesy Julius King Optical Co.

Goggles should be as light as possible. Lenses should be of the best quality glass and free from imperfections. They should be circular in shape and at least 2″ in diameter,

to permit ordinary eyeglasses to be worn under them. The lenses should be easily replaceable, so that new lenses may be inserted in the frame when the old ones become damaged. Side protectors should be placed on all safety goggles. (Fig. 105.) Metal parts should be rust-proof, and easily adjustable by bending to conform to the shape of the face.

Fig. 107

Electric lamp bulb covered with a deposit of fine emery dust from grinding wheel below. This vividly illustrates the need of an efficient exhaust system to remove all dust while grinding, and of wearing suitable goggles to protect the eyes.

Courtesy Julius King Optical Co.

Goggles should be worn when grinding, buffing, handling molten metal, babbitting, chipping, filing, riveting, stone cutting and lumping, drilling, welding, sawing, handling acids, alkalies and other dangerous chemicals, and for all other operations where the eyes are exposed to extraordinary danger.

Special types of goggles should be selected for certain kinds of work. Chippers' goggles should be constructed with extra thick lenses of tough glass, to avoid easy breakage. Boiler firemen require amber colored or slightly smoky colored lenses, to protect their eyes from the glare of the fire. Steel furnacemen should use cobalt blue lenses of a uniform shade. Dark green lenses are best for oxyacetylene welders. Electric arc welders require a combination of red and blue lenses to give the effect of a deep violet color which will protect their eyes from the ultra-violet rays. A helmet is necessary in electric arc welding to protect the face from intense heat. (Fig. 108.) Sand blast operators should wear dust proof hoods with inserted lenses. (Fig. 109.) The

hood should be arranged to exclude every particle of dust. It should be made tight around the neck by means of a sliding strap, the air being taken in through a filter gauze and sponge in the mouthpiece. A light helmet should be

FIG. 108
Helmet in use while arc welding.
Courtesy Julius King Optical Co.

fastened inside to protect the head and keep the hood in place.

Workmen should be required to use fine portable screens when chipping, to prevent flying chips from injuring the eyes of others. These portable screens should also be used in stone cutting and lumping. Wherever there is danger

of injuring the eyes of passersby, portable screens should be employed.

Respirators. — Respirators should be worn when working in an atmosphere laden with dust, or containing harmful vapors and fumes. They are especially important if the atmosphere contains irritating or poisonous gases. Respirators should be provided with a pneumatic cushion, fitting snugly about the face. The vision should not be obstructed in any way. The respirator should contain a removable sponge which may be taken out for frequent washing.

FIG. 109
Hood, with respirator attachment, used for sand blasting.
Courtesy S. F. Hayward Company, New York.

If respirators are not worn, when working in a dust laden atmosphere, the lungs gradually become filled with minute particles. These little particles seriously injure the lungs, preventing them from efficiently performing their function.

Hand Tools. — A vast number of accidents may be directly attributed to the use of improper and defective hand tools. Tools with burred or "mushroom" heads, or loose and defective handles, should never be used. (Fig. 110.) The danger in using these ragged edged tools is readily apparent. If the tool is hit a glancing blow, a piece of steel from the edge may fly at high velocity into a workman's eye. Many eyes are rendered visionless from this cause. Such tools should be regularly trimmed by a blacksmith. When using such tools, goggles should always be worn. Tools should be periodically inspected, and no tools which are in a dangerous condition should be issued.

Badly worn lifting jacks are a source of danger. Files without handles should not be used, as there is danger that

the handle point may be accidentally rammed into the palm of the hand. The handles of hammers, sledge

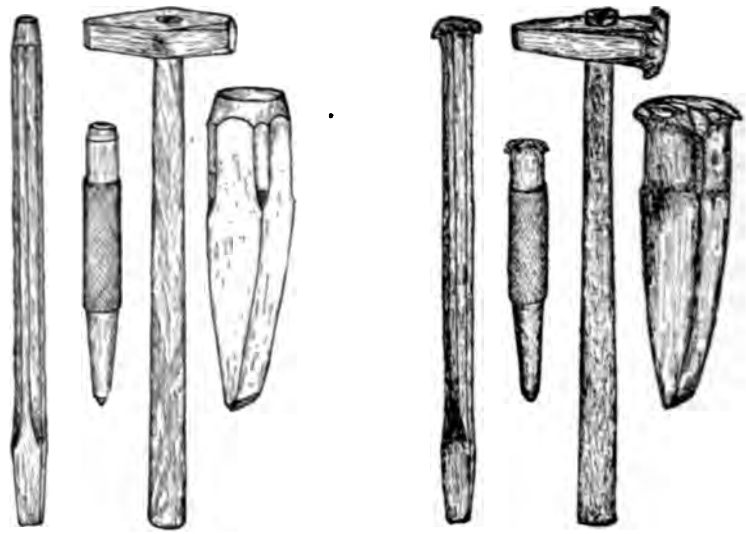


FIG. 110
Safe and unsafe hand tools.
Courtesy Brown & Sharpe Mfg. Co.

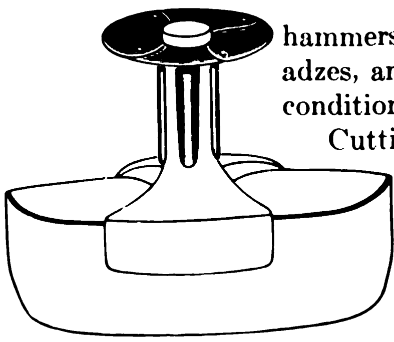


FIG. 111
Safety handle for shoe die.
Courtesy J. K. Krieg Company, New York.

hammers, axes, picks, shovels, hatchets, adzes, and mallets should be in sound condition.

Cutting dies for various uses should be provided with long handles, so that the tools may be held in position with safety when cutting. Safety handles should be used with hand drills, chisels, and punches, to avoid injuring the hands by hammer blows. Dies of various kinds may also be provided with safety handles. (Fig. 111.)

Hammers should be made with corrugated heads to

prevent the heads from glancing off nails as the latter are being driven.

Workmen should be cautioned against striking highly tempered steel with a hammer or similar tool. Tempered steel is so brittle that chips are likely to fly if it is hit a sharp blow. Blacksmiths should use care in tempering hand tools. Highly tempered tools for chipping, or for similar operations, are dangerous, for the reason above stated.

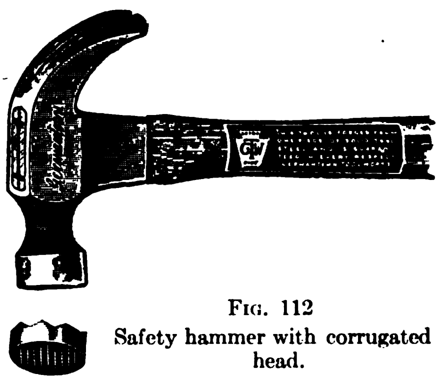


FIG. 112
Safety hammer with corrugated head.
Courtesy Germantown Tool Works.

Accidents caused by the slipping of wrenches are frequent. The type of wrench shown in Fig. 113 is much safer than the ordinary wrench, and is more practicable for many purposes. The use of this style wrench will greatly decrease the danger of bruising knuckles. The greater the pressure exerted on the handle of the wrench, the tighter it grips.

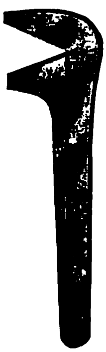


FIG. 113
Safety wrench.
Courtesy Shaw Propeller Company, Boston.

Ladders. — All portable ladders should be equipped with safety shoes to prevent slipping. Steel spurs, "porcupine" feet, or basswood shoes should be used in connection with wooden flooring. (Fig. 114.) Carborundum, basswood, or lead shoes should be used for concrete, brick, and stone flooring. The shoes should be so pivoted that the ladder may be placed at a steep angle without danger of slipping.

Ladders used for work on shafting should be equipped with substantial hooks at the top which fit over the shaft. Stationary ladders should be continued upward at least 3 feet above a platform or landing. Stepladders should

also be provided with safety shoes. Some material, such as corrugated rubber, should also be placed on the treads, to prevent slipping. Stepladders should be equipped with a self-locking device to prevent them from accidentally collapsing when in service.

Rungs of ladders should be spaced from 10" to 12" apart. Stringers or uprights should be placed at least 15" apart to afford a safe footing. Ladders should be maintained in excellent condition and frequently inspected. Unsafe, defective ladders should be discarded.

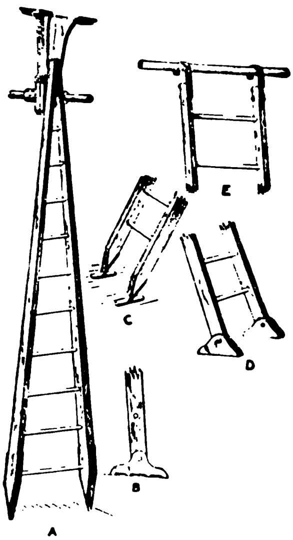


FIG. 114
Safety shoes and hooks for ladders.
Courtesy Mining Journal.

Great care should be taken to place ladders in a safe position before use. They should be inclined at an angle of about 15° from the vertical. They should never be placed upon barrels, kegs or boxes, especially when empty, as these objects do not afford a safe support. All permanent ladders should be of steel and securely fastened. Ladders to footways on scaffolds should be fastened at both the top and bottom by means of cleats. Material should not be carried up and down ladders. It should be hoisted or lowered by means of a hand line. Workmen should have the free use of both hands in climbing or descending. Where a ladder cannot be placed in a safe position for any work, an assistant should be summoned to hold it while a workman is using it.

Traffic. — The proper handling of large crowds in congested parts of cities depends upon efficient police service. Persons should not attempt to cross city streets except at regular crossings, and then only upon the proper signal from a policeman. Before crossing, persons should look

both ways to make sure they can cross in safety. In crossing a street, one should always look to the left until half way across, and then look to the right for the remainder of the way. Thus one will always be looking in the direction of approaching vehicles and cars. If the public would co-operate with the police and observe these simple rules, there would be few accidents at these places. The building of underground passageways at congested crossings in large cities should be encouraged. This would eliminate much of the danger. Rules for slow automobile driving in cities and towns should be strictly enforced.

Every municipality should, so far as it is possible and necessary, designate by white painted lines, several inches wide, safety zones and crosswalks on its streets. Policemen should be instructed to restrain pedestrians from crossing streets so marked except when within the indicated safety zone. These zones should be kept free from obstructions at all times. In addition, "GO" and "STOP" signal stands should be erected in the center of the square at all important crossings. These should be operated by the attending policeman. In this way traffic may be safely and easily regulated.

All streets that are undergoing construction or repair should be safely fenced off or blockaded. Large warning signs, stating that the street is closed, should be placed at each end of the section.

Dangerous curves on highways should be conspicuously marked by large warning signs — "DANGEROUS CURVE" placed at the proper distance from each end of the curve. Caution signs marked — "SCHOOL — GO SLOW" — should be conspicuously placed on sides of a street approaching a schoolhouse.

The majority of automobilists, pleasure drivers, chauffers, and teamsters are extremely careless in approaching cross streets and railroad crossings. They make no attempt to slow down and look in both directions before crossing a railroad track, and they fail to drive slowly when approach-

ing cross streets and rounding curves. They thus endanger their own lives and the lives of those entrusted to them.

Sidewalks. — Sidewalks are frequently found in an unsafe and dilapidated condition. Slippery coal hole covers, light covers, vent grates, and curbs are common. Broken glass circles in covers and lights form holes which are a menace to pedestrians. Metal surfaces in the walk should be provided with carborundum strips to prevent slipping. Simple corrugations of the metal itself offer very little protection. Sidewalks should be free from obstructions such as hydrants, street sprinklers, steps, and railings. There should be no projections or depressions in the surface of a sidewalk. Granolithic sidewalks are far preferable to any other type. All openings in sidewalks should be protected, and, where possible, gratings should be abolished. Broken parts of sidewalks should be immediately repaired. When coal holes are open, they should be guarded with a portable iron railing. Each coal wagon should be provided with such a guard. Openings formed when trap doors are lifted should be guarded by horizontal bars on each side which hold the doors open.

Teaming and Trucking. — Breakdowns of trucks and wagons, which are heavily loaded, are not uncommon. Hence the desirability of frequent inspection of wheels, axles, springs, king-bolts, brakes, side studs, tailboards and chains, shafts, breeching hooks, seats, whiffletrees, and other parts. Wagons and trucks are often overloaded, or unevenly loaded, thus causing breakdowns or overturns. Loads should not exceed the capacity of the carrier. They should be properly blocked and secured to prevent slipping or shifting. The ends of long objects, such as pipes, rods, lumber, etc., which project beyond the rear of a wagon or truck, should be covered with padded burlap, with a red flag attached, so they cannot seriously injure a careless person by whipping or swinging up and down while passing through the streets. Parts of a harness may break at a critical and unexpected moment, causing much damage.

Teamsters should be instructed to make a careful inspection each day of their wagons, trucks, and harnesses, before starting out. They should be warned against driving on or between railroad and trolley tracks. They should be cautioned to drive slowly between buildings and around the corners of buildings. Drivers should never leave their wagons and trucks in the middle of the street or road. This causes inconvenience to others, and endangers life and property. The rules of the highway should be observed at all times. Drivers should keep to the right, and avoid passing others when going around curves. Vehicles should be provided with proper lights which should be lit at sundown. A light should be placed at the extreme left of a vehicle to show the point of clearance, with a red light in the rear.

Heavy teaming and trucking on asphalt pavement should be avoided as far as possible, especially in rainy or in winter weather, as it is then almost impossible for horses to secure a safe footing. Thus falls are numerous. Horses should be kept sharply shod, especially in winter weather. A safety shoe, which may be attached to the hoof of a horse, is now on the market.

Drivers should prevent children from stealing rides where their safety would be endangered.

Firearms. — Accidental shooting often occurs because careless persons fail to ascertain whether or not a gun or pistol is loaded. Loaded firearms are sometimes pointed by one person at another in an attempt to frighten, or in play, the bearer believing the arm to be unloaded. Accidental discharge then takes place, frequently causing a death or a serious injury. The pointing of any firearm toward another person, even though it is known or believed to be unloaded, is an exceedingly dangerous practice. Great caution should be used in handling, loading, and cleaning firearms. They should always be unloaded before cleaning. No firearm should ever be placed in the hands of a novice.

CHAPTER XXIII

RULES FOR FOREMEN AND GENERAL RULES

RULES FOR FOREMEN

1. Accident prevention is one of the foreman's most important duties; one that will require earnest determination and constant vigilance. The loss and waste involved in industrial accidents are enormous. Accidents increase the cost of production; cause sorrow, suffering, and distress, and impose a heavy social burden. No shop can be considered highly efficient that has many accidents. Frequency of preventable accidents among employees is a charge against a foreman's efficiency.

2. Have a thorough understanding of all the safety rules. Unless you know them all, are living up to them, and enforcing them, you are not doing your full duty.

3. It is your duty to see that all safety rules are observed by your men. You will be held personally responsible for preventable accidents to the men under you.

4. Caution your sub-foremen regarding the prevention of accidents, as you are also responsible for the safety of the men working under them.

5. Judgment should be used at all times in placing men on jobs. Heavy, slow men should not be placed on jobs where light, quick men are required. Slow-thinking, untrained men should not be placed around machinery, or any place, where presence of mind and knowledge are required, for, by so doing, the hazard is increased.

6. If the same men are frequently injured, put them where they cannot get hurt.

7. Do not place a man at new work unless he understands his new duties. If he does not understand them, explain them thoroughly to him.

8. Obtain a thorough understanding of each accident, and study how its repetition may be prevented.

9. Drill your men to immediately notify you when injured, no matter how slight the injury may be, and send them to the doctor at once. Even trivial wounds should be cleansed, bound up, and kept clean until they have healed. If not attended to, trivial wounds often become infected and result in serious consequences.

10. Every foreman should make a weekly report of conditions in his department on a form provided; and he should report any conditions that should be made safer, or which will increase efficiency.

11. You should not put men to work on any job until you have inspected everything, and satisfied yourself that the place is safe. You should warn the men of any danger that may arise in the course of performing their work, and

watch to see if your instructions are complied with. If you see a man violating your instructions, or taking unnecessary chances that place him, or his fellow-workmen, in danger, deal with him so as to make it certain that he will not again disobey orders.

12. Injured men should not be allowed to go unassisted to the doctor, if the injury be serious.

13. Never have two men working together who cannot understand each other.

14. Particular attention should be given to the fire-fighting apparatus. Acquaint yourself fully regarding it. See that it is always in place, and ready for immediate use.

15. Should any employee disobey your instructions, explain to him the reason why instructions were given, and the danger to himself and other employees. If he persists in disobeying, he should be severely dealt with.

16. Take notice of all reports or complaints of unsafe places, appliances or conditions; investigate the same thoroughly, and remedy the conditions where possible.

17. When a job is finished, see that the safeguards are properly replaced, and all loose material removed. Do not allow machinery to be started before all safeguards have been replaced. If it is necessary to start the machinery without safeguards for the purpose of testing it, be sure that everyone is out of danger.

18. Make it your personal duty to see that the safeguards and signs, installed to promote safety, are always in place and in good condition.

19. Foremen should see that machinery and all other appliances are maintained in safe condition, and that they are suitable for purposes intended; also, that exposed gearing, pulleys, belting, etc., are protected with shields, guards or railings, as necessity requires. Belt shifters should be used in all cases for shifting belts.

20. All appliances and safeguards should be frequently and carefully inspected; and if machinery, tools or other appliances are dangerous, do not continue to use them, but report their condition to the Safety Department.

21. Be constantly on the lookout to see how conditions in your department can be kept safe and made safer. Unless you can properly make the improvements yourself, send all suggestions to the Safety Department. Constant vigilance is the price of safety.

GENERAL RULES

1. All employees should remember that, while every man is employed to do some particular work, the safety of himself and his fellow-workmen is more important than that work. Obtaining safe conditions is a matter of becoming more efficient. The study of safety is the study of the right way to do things. It will increase the efficiency of the work. Careful men are usually safe and efficient. Careless men are neither.

2. Employees who wilfully disregard these rules, or show contempt for their own or their fellow-workmen's safety, should be discharged. Careless men should be cautioned. If they continue to show that they are a danger to

their own and their fellow-workmen's safety, they should be transferred to positions where there is the least possible chance for them to harm themselves or others, or they should be discharged.

3. Heads of departments and employees should be courteous to one another at all times. Co-operation between departments is absolutely essential.

4. The use of intoxicating liquor should not be tolerated in the plant. Any employee, reporting for work under the influence of liquor, should be laid off or discharged. Hard drinkers should never be employed. The use of liquor by employees outside of their work should be discouraged. Those who do not drink should be given preference for promotion.

5. Men discharged for cause from one department should not be permitted to work in another department without the consent of the previous foreman, or unless authorized by the Department Manager.

6. It is the duty of each employee to report every unsafe or dangerous condition he sees to his foreman or to the Safety Department, or drop a memorandum of it into the Safety Suggestion Box. Any foreman receiving such a suggestion or notice should promptly remedy the unsafe condition, or report it promptly to the Safety Department.

7. Loitering about the departments should be prohibited.

8. During working hours, workmen should not engage in conversation, nor concern themselves with other matters that may be interesting, but that do not pertain to their work.

9. Never disregard a warning sign. It has been placed there for a reason.

10. Never fail to use a safeguard provided, and, under no consideration, remove a safeguard unless you are authorized to do so. There is a severe legal penalty against removing safeguards. If, for any reason, it seems necessary to remove a safeguard, be sure to get the permission of the foreman.

11. Wrestling, throwing of material, or fooling of any kind, should be positively prohibited.

12. Fighting should be strictly forbidden, and those responsible for fighting should be discharged. The foreman should stop fighting, if possible, and should promptly report any fighting, with the names of participants, to his department head.

13. Keep off railroad tracks except at regular crossings. Never walk the tracks to and from work. Before crossing any track, stop, look, and listen.

14. Smoking should be strictly prohibited in all parts of the factory.

15. Goggles should be worn when grinding, buffing, chipping, filing, roughing, finishing, babbitting, handling molten metal, or in other instances where the eyes should be properly protected.

16. Never strike tempered steel with a hammer or other tool. Pieces are likely to fly into the eyes.

17. Never take short cuts over dangerous places. Do not leave work to go to other parts of the plant except on company business.

18. Good, stout soles on shoes prevent injuries from nails and jagged pieces of steel, broken glass or other material.

19. Employees should be forbidden to wear celluloid eye shields, cap visors, collars, etc. This material is very inflammable, and is likely to ignite from a spark or intense heat.

20. Always thoroughly inspect planks and scaffolds before doing any work upon them.

21. Never remove a guard while the machinery is running.

22. Never touch a valve, switch, clutch, belt shifter or other parts of machinery, unless your duties require it. Never operate a machine with which you are unfamiliar.

23. Never leave tools and material about the aisles or working places for others to stumble over. Keep all machinery and working places clean and neat at all times.

24. No tools should be used having burred or "mushroom" heads, or loose and defective handles.

25. Never use a candle, lighted match, oil lamp, torch or any other open light, in a room, or near any other place, where gasoline or other volatile, explosive or inflammable material is stored or used. Use an electric lamp, protected with a wire guard, and see that the wires and connections are well insulated. Never smoke under these conditions. Gasoline is especially dangerous, and it should be issued in safety cans supplied by the company. Not more than a day's supply should ever be issued, and any left over should be returned at night.

26. Never go to work when ill or partially incapacitated. If you become ill, quit work before an accident happens. Your own best interests, and those of your employer, require this. A person with serious physical ailment is peculiarly susceptible to danger.

27. Never work about machinery if there is insufficient light.

28. Installation of new machinery, or change or alteration of existing machinery, should only be undertaken after conference with the Safety Department. No new or changed machinery should be put into operation until approved by the Safety Department.

29. If you are injured, no matter how little, report it to your foreman at once. Go to the doctor, no matter how trivial your injuries. Never attempt to pick out anything from another person's eye. Send him to the doctor.

30. Employees should be forbidden to rest upon, or lean against, any railings or guards built upon, or alongside of, any dangerous places or machinery.

31. Employees subject to epilepsy or fainting spells, or any other chronic affliction which causes loss of consciousness, should not be retained in any department in which there are dangerous conditions.

32. There are usually some employees who, through stupidity and carelessness, are frequently injured. Such men should not be retained in the company's employ, or if retained, should be placed at work where the chances of injury are remote.

33. Employees should not throw oily waste, food scraps, waste paper or other refuse, inside of buildings or out of windows. Waste garbage cans should be provided. The piling of oily waste under benches, or in out-of-the-way corners, should be positively prohibited.

34. If you make an opening, or remove the cover from any opening in the floor, ground or other place, guard that opening.

35. Workmen should be forbidden to hoist any material by means of line shafting. All hoisting should be done either with hand block and tackle, or with regular hoisting machinery.

36. Every employee whose duties require him to work with machinery or appliances, or tools of any kind, should examine them daily, and report promptly to the foreman any defect found.

37. Never carry material up or down a ladder. Use a hand line.

38. Do not turn on any air, steam or water, or set in motion any machinery, or throw down any material, without making sure that no one is in a position to be injured.

39. After repairing machinery, always properly replace the safeguards before leaving the work. When the work is completed, never leave tools and material overhead or around, but make the proper disposal of them. Tear down all temporary scaffolds as soon as the work is finished.

40. Boards containing protruding nails should not be left lying around. Many accidents are caused from stepping on protruding nails in loose boards. When you see such boards, turn them over and pull out the nails, or put the boards where they can do no harm.

41. Always remove protruding nails after taking off the heads of barrels, kegs, or covers of boxes. Leave no metal scraps, broken glass, or other rubbish about, which may cause injury to anybody.

42. Workmen are warned not to stand upon the heads of empty barrels, kegs or boxes.

43. Care should be taken by men, working above other men, that they do not drop any material. When men are so working, they should place a sign beneath, "DANGER — MEN ABOVE." When you are going to work above or below other men, let those men know about it. Men working on high elevations from which they are likely to slip, or when working on smokestacks or roofs, or when washing windows, etc., should wear safety lines and belts.

44. All persons, not authorized by the Chief Electrician, should be forbidden to work upon any electrical apparatus. They should be warned against touching wires of any kind. Before doing any work where there is danger of coming in contact with electric wires, notify the Chief Electrician, who will send an experienced man to advise concerning the work. Do not try to fix the electric lights, but call the foreman.

45. Employees should be forbidden to ride on engines, cars, overhead or locomotive cranes, elevators, or other moving bodies, except when required to do so by their duties.

46. Do not fool with compressed air. Never blow the air on anyone. It may injure or kill him.

47. Employees handling lumber, stones, brick, pig iron, sheet metal, metal scrap, glass and other material with sharp edges or projections, should wear gloves or mittens.

48. Never taste of any chemical or liquid out of curiosity, nor drink from a glass in which chemicals have been used. Never leave poisonous substances about where others may come in contact with them. Keep them under lock and key.

49. Never throw anything out of a window.

50. Obtain a thorough knowledge of the location of all fire apparatus, and of how to use it; also, know the location of all fire alarms.

51. Keep cool and calm in case of fire. Use your influence to maintain order and prevent a panic.

52. Workmen, foremen, and inspectors should report any steam or water joints which are leaking.

53. Workmen, while carrying an open light, should not enter oil houses or pits which are oily, or which contain grease.

54. No employee should go into an engine-room, electric motor-room or boiler-room, unless his duties require it, or unless he has received special instructions from the foreman.

55. Be careful, when handling acid, not to let it splash on your clothes or person.

56. Always use the handles when moving acid carboys.

57. When removing drillings from the drill, or removing shavings from lathes, milling machines, etc., be careful not to get caught by the machine. Stop the machine first, or use something other than the hand to remove drillings and shavings.

58. Employees should not spit upon the floors, passageways or walks. Receptacles, provided for the purpose, should be used.

59. No one should handle, or assist in handling, dynamite or any high explosives or chemicals, unless he has received instructions satisfactory to the superintendent of the department.

60. Vigilance and watchfulness promote safety. To avoid danger, the safe course should be adopted. Employees should never depend upon anyone else for their own safety.

CHAPTER XXIV

SANITATION, ILLUMINATION, HEATING, AND VENTILATION

Sanitation

UPON proper sanitary conditions, both in the factory and the home, depend the health and efficiency of employees. A very large proportion of the laboring class is utterly ignorant of the principles of personal hygiene. The condition of some of the workshops in our large cities is a disgrace to humanity. Many shops still exist with an insufficient number of water closets, with flushes out of order, with cracked and dirty seats, with old wooden boxing about the bowls, with no supply of paper, with faulty plumbing, and with closets clogged with refuse. Many closets are located in cellars where there is no light or ventilation. Male and female closets are often found improperly separated. Indescribable conditions exist in the congested parts of large cities where the struggle for existence has smothered the progress of civilization.

The beneficial effect of a clean, sanitary factory, well lighted and ventilated, is always reflected in the efficiency and loyalty of employees. Clean floors, freshly painted walls and ceilings, clean windows, sunlight, and a neatly kept factory are essential.

Following are the general specifications for sanitary installations by the subsidiary companies of the United States Steel Corporation:

WATER CLOSETS

Location:

(*a*) Closets should be so located to be as convenient as possible to the work.

(*b*) There should be a number of small installations, rather than a few large ones.

(*c*) Each toilet room should be so located as to open to outside light and air. The minimum amount of window space for a toilet room containing one fixture must be four square feet, and for each additional fixture an addition of two square feet of window space must be made. These windows must be so constructed that they can be opened to give adequate ventilation to the room. Each toilet room should not have less than ten square feet of floor space and not less than one hundred cubic feet of air space for each fixture installed.

(*d*) Closets should be separated from lockers and wash rooms by partitions or otherwise.

(*e*) Unless wash rooms are in close proximity to closet, each closet should be supplied with at least one wash basin.

(*f*) An adequate number of urinals should be provided in each closet.

Character of construction:

(*g*) Number of seats should not be less than one to every fifteen persons, based upon the maximum number of employees in a turn in departments using the unit.

(*h*) Closets should be of individual bowl type, and should be made of porcelain or vitreous china, and not of enameled iron.

(*i*) Every bowl should be separately vented and trapped.

(*j*) The seat of each water closet should be made of wood or other non-heat-absorbing material and finished with varnish or other substance which will make it impervious to water. Under no circumstances should seats be made of enameled ironware, porcelain or other similar heat-absorbing substance.

(*k*) The size of the opening should be at least seven inches in width and eleven inches in length.

(*l*) There should be partitions between the seats, preferably of steel construction, enameled but not porcelain, six feet in height and twelve inches off the floor.

(*m*) Distance between partitions should not be less than thirty inches, and distance from front of seat to door not less than thirty inches.

(*n*) Partitions and bowls should be so arranged that the entire space behind and below the seat can be easily cleaned.

(*o*) Doors should not be less than twenty inches in height. If of this dimension, the lower part of the door should be placed twenty-four inches above the floor.

(*p*) Clothes hooks should be provided.

(*q*) Toilets should be adequately heated in cold weather.

(*r*) Heating facilities should be so arranged as to permit proper cleaning of floors and walls.

(*s*) Floors should be constructed of glazed tile or concrete, with a smooth surface. They should be non-absorbent.

(*t*) Walls should also be made of non-absorbent material with a smooth surface, preferably glazed, not only to facilitate cleaning, but to avoid defacement. Corners should be of the cove type.

(*u*) Walls and partitions should preferably be light colored to increase illumination and to facilitate cleaning.

(*v*) Hose connection should be provided.

(*w*) Toilet paper with proper holders should be furnished by the company.

(*x*) Regular and thorough cleaning should be adopted. Disinfectant is not to be relied upon.

(*y*) Someone should be especially delegated in attendance.

Construction of the closet where there is no sewerage system:

(*a*) There should be sufficient light.

(*b*) There should be proper ventilation.

(*c*) The hole in the seat should be at least seven inches in width and eleven inches in length.

(*d*) For each hole there should be a close fitting cover.

(*e*) All privies should have provisions for cleaning.

URINALS

(*a*) An adequate number of separate urinals should be placed throughout the mill convenient to where men work.

(*b*) Troughs and basins should not be used for urinals. The wall or vertical slab urinal, with proper flushing, should be used; preferably the porcelain stall.

(*c*) There should be protection around the urinals to secure privacy.

(*d*) Floor in front of urinals should slope to drain.

SANITARY DRINKING WATER FOUNTAINS

(*a*) Fountains should be located convenient to where men work.

(*b*) They should be made attractive, preferably white in color, and kept clean.

(*c*) They should be so designed as to make it impossible for a person, when drinking, to put his lips on the outlet for water.

(*d*) They should be so constructed that of necessity a person must drink from a stream or jet, not from an overflowing bowl.

(*e*) They should be so arranged that waste water will be carried away without slopping.

WASH AND LOCKER ROOMS

Location:

(*a*) Washing rooms should be located in places most convenient to the men to be served, and if possible along the route when going from work, and without exposure to the weather.

(*b*) So far as possible, they should be located in places where the men are least exposed to accident hazards while en route.

(*c*) They should preferably be located in a separate building, or if within a building, they should preferably be enclosed.

(*d*) They should be open to outside light and air.

Building:

(*e*) If a separate structure, the building should be of substantial fire-resisting construction.

(*f*) Wash and locker rooms, located in the same building with toilet, should be completely separated by a partition. These rooms may be joined by swinging or self-closing doors. It is preferable that wash and locker rooms be separated by partitions.

(*g*) The rooms should be of sufficient size, so that the men can conveniently use equipment without interference.

(*h*) Floors and walls should be of concrete or non-absorbent material. Floors should slope toward the drain.

(*i*) Drain should be located under equipment, so water will run toward and not away from fixtures.

(*j*) Walls, ceilings and partitions should be light in color to give a neat appearance, to increase illumination, and to facilitate cleaning.

(*k*) Sufficient window space should be provided to give adequate light and ventilation.

(*l*) Rooms should also be adequately lighted, artificially. Light should be so distributed that fixtures are thoroughly illuminated, no dark corners being allowed to exist.

(*m*) The room should be provided with adequate and suitable heating facilities.

(*n*) Heating pipes or radiators should be so installed as to give ample space below and behind same for cleaning purposes.

(*o*) Permanent hose connections should be provided for thoroughly flushing and cleaning rooms.

(*p*) Clothes hooks should be provided.

Fixtures:

(*q*) Basins or troughs for common use should be installed. Facilities for washing hands and face should be such that of necessity a person must wash from a flowing stream.

(*r*) The number of faucets for washing hands and face should not be less than one to every six employees, based upon the maximum number employed on a single turn in the department using the equipment. Regular showers may be substituted for faucets.

(*s*) Fixtures for washing the face and hands should be so spaced that a person can wash conveniently without splashing his neighbor.

(*t*) Both hot and cold water should be provided for each fixture.

Lockers:

(*u*) A locker or other method of caring for change of clothing should be provided for each employee who has a fixed place of work.

(*v*) Lockers should be of steel with proper provision for ventilation. They should be at least six inches off the floor.

(*w*) Size of lockers should not be less than 12″ × 15″ floor space.

Showers:

(*x*) The number of showers should not be less than one to every twenty-five employees, based upon the maximum number employed on a single turn in the department using the equipment.

(*y*) Each shower should be separated by a partition.

(*z*) The enclosure should be finished in a light color to give a neat appearance, and to facilitate cleaning.

(*aa*) Showers should be provided with hot and cold water, and should be equipped with a hot and cold water regulating valve.

(*bb*) Regulating device should be so located that it can be operated without standing under the shower.

(*c*) Supply pipes to showers should be overhead in order to avoid the possibility of a person coming in contact with a hot pipe, and also to facilitate cleaning of the shower enclosure.

Care:

(*d*) Special men should be delegated to attend to cleaning of wash rooms.

Employers should provide individual cloth towels, or roll paper towels, for the use of employees. The roll cloth towel, an active medium of spreading disease, should be universally abolished. Drinking cups, other than sanitary paper cups, should not be used.

Water Supply. — It is important to acquire and maintain a pure water supply. It should not be possible for natural or artificial drainage to contaminate the supply in any way. Chemical analyses of the drinking water should be made periodically. Impure water should be properly filtered. Much disease is spread by the use of contaminated drinking water; therefore, all possible precautions should be taken to keep the supply free from dangerous impurities.

Pure Food Supply. — Food should not only be pure, but it should be kept pure until consumed. Cloth netting should be placed over vegetables and fruits in warm weather to keep flies away. Screens should be employed to prevent flies from crawling over meats and other foods. Glass covers should be used in restaurants. White sanitary garments should be worn by butchers, grocers, and others who handle foodstuffs. Floors should be kept free from dust and dirt. Before being swept, they should be covered with damp sawdust to prevent dust from rising. Glasses at soda fountains and other places should be kept in cabinets. Candies should be kept in cases. Milk should be delivered in sanitary cans and bottles. Dairies should be kept scrupulously clean. Unless the strictest sanitary precautions are observed, a great deal of disease will be spread through the medium of impure milk.

Garbage Removal. — Proper attention should be given to the removal and disposal of garbage. Garbage and ref-

use cans with covers should be placed in lunch rooms for employees, and in other places about the factory. Employees should be forbidden to throw waste food and refuse elsewhere. These cans should be emptied daily, and the refuse burned. Rats and vermin often hover about garbage and refuse, spreading disease in various ways. If present, they should be trapped, destroyed, and buried.

Expectoration. — Promiscuous expectoration spreads much disease. To avoid this, cuspidors should be located at convenient places about the factory. They should be kept filled with a disinfectant solution, and should be washed and emptied daily. Employees should be forbidden to expectorate upon the floors, walls, passageways, and walks. City ordinances should forbid persons to spit upon sidewalks, in public conveyances, and in other public places. This should be made a misdemeanor, punishable by a fine. When sputum is deposited on floors, walks, or similar places, it dries in a short time. It may then be blown into the mouths and nostrils of persons, spreading disease in this way. Sputum may contain the germs of tuberculosis, syphilis, and other contagious diseases.

Houseflies. — The common housefly is responsible for much disease. It often carries the germs of typhoid fever, dysentery, tuberculosis, diphtheria, and many other diseases. As many flies as possible should be destroyed each year.

Houseflies are hatched from eggs which are deposited upon moist, rotting or fermenting matter. The heat generated by the fermentation or decomposition assists the process of hatching. The female fly prefers to lay her eggs in moist horse manure, but where this is absent, any form of filth will serve her purpose. Privies and privy drains are common breeding places. The eggs deposited by the female fly total from 100 to 150 at a time, being hatched in from eight to twenty-four hours in warm weather. Each egg produces a small white maggot. This maggot undergoes several changes, becoming a full grown fly within ten days. One nest or group of eggs produces at least fifty

female flies which are ready to lay their eggs within ten days from the time they emerge from their breeding place. This illustrates the enormous reproducing power of these insects.

After the fly is hatched, it seeks places of filth containing all kinds of germs. As the fly crawls over this filth, germs attach themselves to its legs and body by the thousands. The fly then enters the home, or other places, crawling over food on which it deposits many germs. Before eating, the fly moistens its food by expectorating upon it. This spittle also contains the germs of disease. This emphasizes the importance of eliminating the housefly.

Mosquitoes.—Mosquitoes are also to be feared. They carry the germs of malaria, yellow fever, and other diseases. Mosquitoes breed in stagnant pools, swamps, sluggish river banks, marshes, and similar places where there is still water. Such places should be drained dry, or covered with a film of oil on the surface of the water, to prevent mosquitoes from breeding. Underbrush and weeds should be cut away, and the surroundings cleared.

Illumination

Insufficient light is a common contributing cause of accidents. Adequate and proper light conditions should prevail in the factory and workshop. If daylight is poor, artificial light should be employed. Daylight may be greatly increased by painting white the inside of workrooms, stairways, and passageways. Windows should be frequently washed. Dirty windows shut out a large amount of useful light. Electricity, on account of its many advantages, is far preferable to any other form of artificial light.

There are three distinct methods of illumination, namely, the direct, semi-direct, and indirect. Direct lighting is, of course, obtained from the transparent bulb, usually supplemented by a reflector. Semi-direct lighting is obtained by diffusing the rays through a frosted glass bowl surrounding the bulb. Indirect lighting is obtained by directing all the rays to the ceiling, whence they are dif-

fused about the room. In the latter case, the ceiling must be of a whitish tint to obtain satisfactory results. These different methods all have their advantages for various purposes. Direct lighting is most commonly used about machinery, especially at the point of operation. This should be supplemented by semi-direct or additional direct lighting.

Machinery and workplaces should be especially well illuminated, otherwise accidents are bound to occur. All dark stairways, passageways, pits, elevators, elevator landings, footways, and runways should be kept well lighted at all times during working hours.

The position and proper shading of lamps, for the use of workers, should receive special attention. Lamps are frequently so placed that they glare directly into the eyes of operators. The reflected light from improperly shaded lamps often strains the eyes of workers. Lamps should be so placed and shaded that direct or reflected light will not be cast directly into the eyes. Lamps should not be placed too near, nor yet too far from the work. The intensity of the light should not be too great, yet sufficient light should be obtainable. Illumination should be an aid to the sight, instead of a hindrance and a strain.

It is common knowledge that the number of work accidents increase during the winter months, also that the larger proportion occurs during the hours of diminished daylight. These accidents are increased at these times because of insufficient artificial light. Improper lighting conditions result in much spoiled work, poor quality of work, loss of efficiency, and an enormous number of casualties. In addition, hundreds of thousands of eyes are ruined each year. The importance of providing proper illumination cannot be overestimated.

Heating

During cold weather, workrooms should be properly heated by means of steam or hot water. Insufficient heat

reduces the resisting power of workers to disease. On the other hand, a too high room temperature tends to decrease their efficiency. A temperature of about 66 degrees is a good medium. The temperature of the workrooms should remain constant during working hours. In the hot summer months, workrooms should be cooled by means of an effective ventilating system. The temperature of the

FIG. 115
Nickel plating tanks showing exhaust system for acid fumes and steam, also covers for tanks.
Courtesy Eastman Kodak Company.

workroom has a more important bearing upon both health and efficiency than is generally supposed.

Ventilation

Ventilation is another factor, too commonly overlooked, which has a direct relation to health and efficiency. A contaminated atmosphere spreads the germs of disease and

stupefies the minds of the workers. Fresh air is necessary for good health and an active brain. Fresh air and sunlight tend to kill germs. Each workroom should be especially well ventilated. If natural ventilation is inadequate, artificial ventilation should be employed.

All rooms in which dust is created should be artificially ventilated. Exhaust hoods should be placed over all machines which create dust; also, over vats and tanks which emit poisonous or irritating vapors and fumes, such as mercury, lacquer, varnish, gas, acid vapors, etc. (Fig. 115.) Hoods should be provided for melting pots, typesetting machines, ladles, furnaces, forges, etc. Air blasts should be installed at muffle furnaces, to blow cool fresh air into the faces of workmen, thus relieving the intense heat. Hoods should be used to exhaust sulphur fumes wherever generated. Dust arresters should be placed on woodworking machinery, wherever practicable; on emery wheels, buffing wheels, rag cutters, flour mill machinery, tumbling barrels, cotton mill machinery, and all grinding and crushing machinery wherever possible. Exhaust fans of sufficient capacity should be installed.

CHAPTER XXV

WELFARE WORK

LARGE corporations throughout the United States are now engaged in carrying on extensive welfare work among their employees. No expense is being spared in making the living and social conditions among the workers as pleasant and attractive as possible. Hospitals, visiting nurses, medical examination of employees, club houses, libraries, night schools, manual training schools, lunch rooms, gymnasiums, billiard rooms, bowling alleys, swimming pools, baseball fields, playgrounds for children, kindergartens, improved bungalows and dwellings, parks, voluntary relief plans, pension systems, and stock subscription plans comprise the important steps which are being taken to make desirable citizens of the vast army of workers and their families. This work is of great importance from the sociological and educational points of view. The result is that the workers become more efficient and far better satisfied with their lot. In hours of leisure the workers find time and opportunity for education, recreation, and amusement. The results of this welfare work are directly reflected in the quality and quantity of the work performed, and in the loyalty and faithfulness of employees.

Medical Examination of Employees. — One of the most important features of welfare work is the compulsory medical examination of employees. For this purpose, many companies engage one or more competent physicians to take charge of the work. In large companies a physician should devote his entire time to this work; in the case of smaller companies, he need devote only a part of his time. Every employee should be thoroughly examined by the

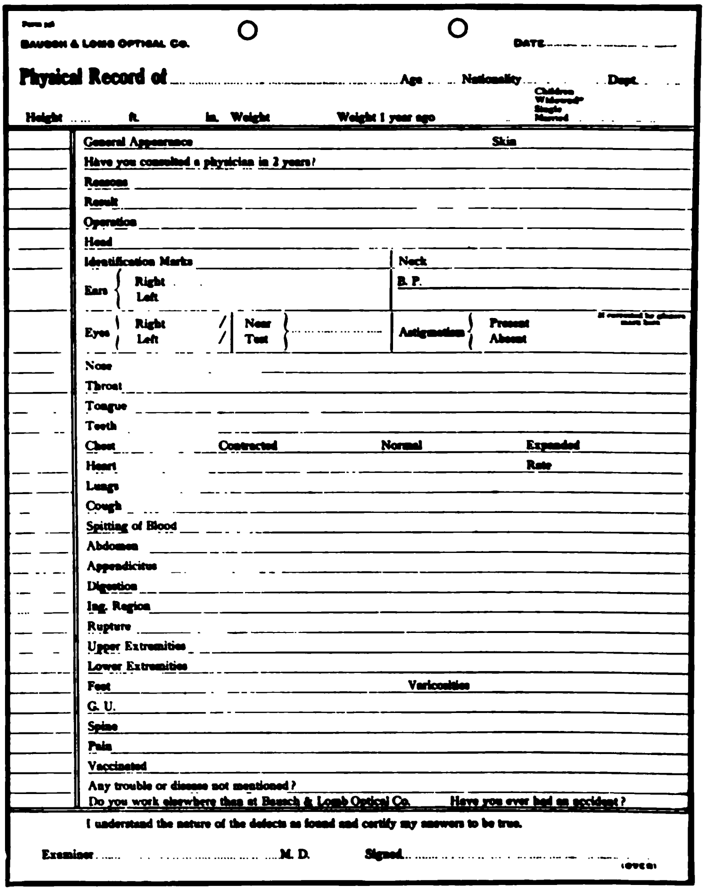
company physician at least once a year, and more often if necessary, for the purpose of discovering illness and physical defects of any kind. The examination should not be conducted for the purpose of discharging workers in poor health, but for enlightening employees of any illness, in order that they may receive proper care and treatment free of charge. Such an examination enables the management to place employees at the kind of work for which they are fitted. Detailed records should be kept of all medical examinations, showing a complete analysis of the health and physical condition of every employee.

The medical examination of employees has an important bearing on increasing the efficiency of any organization. Many employees are found engaged at work for which they are entirely unsuited. Some cannot afford to be treated by an outside physician. In case a worker is suffering from a contagious disease, it may spread throughout the working force. A systematic health supervision over employees would reveal these conditions at once. A medical examination serves to educate employees in the fundamental principles of health preservation and hygiene.

Employees may be interested through health, hygiene, and sanitation talks which are illustrated with stereopticon slides. These lectures and talks attract large audiences, accomplishing much good. Talks and lectures should be supplemented with monthly pamphlets describing different diseases, symptoms, methods of prevention and cure. These should be distributed among all employees, being printed in as many languages as are spoken by the workers. By these methods of education, and by information imparted by the physician during the medical examination, the employees gain a knowledge of the value of good health and how to acquire and retain it.

Every employee who becomes ill while at work should be taken to the company hospital and examined. The employee should be required to secure a "pass" from the company physician before leaving the factory. This sys-

tem will discover a disease in its inception, thus preventing a contagious disease from spreading among the workers. An employee who shows any symptoms of a disease may



BAUSCH & LOMB OPTICAL CO.

DATE

Physical Record of .... Age ...... Nationality ...... Dept. ......

Children / Widowed / Single / Married

Height ... ft. in. Weight ... Weight 1 year ago ...

General Appearance — Skin

Have you consulted a physician in 2 years?

Reasons

Result

Operation

Head

Identification Marks — Neck

Ears { Right / Left — B. P.

Eyes { Right / Left — Near / Test — Astigmatism { Present / Absent

Nose

Throat

Tongue

Teeth

Chest — Contracted — Normal — Expanded

Heart — Rate

Lungs

Cough

Spitting of Blood

Abdomen

Appendicitis

Digestion

Ing. Region

Rupture

Upper Extremities

Lower Extremities

Feet — Varicosities

G. U.

Spine

Pain

Vaccinated

Any trouble or disease not mentioned?

Do you work elsewhere than at Bausch & Lomb Optical Co. — Have you ever had an accident?

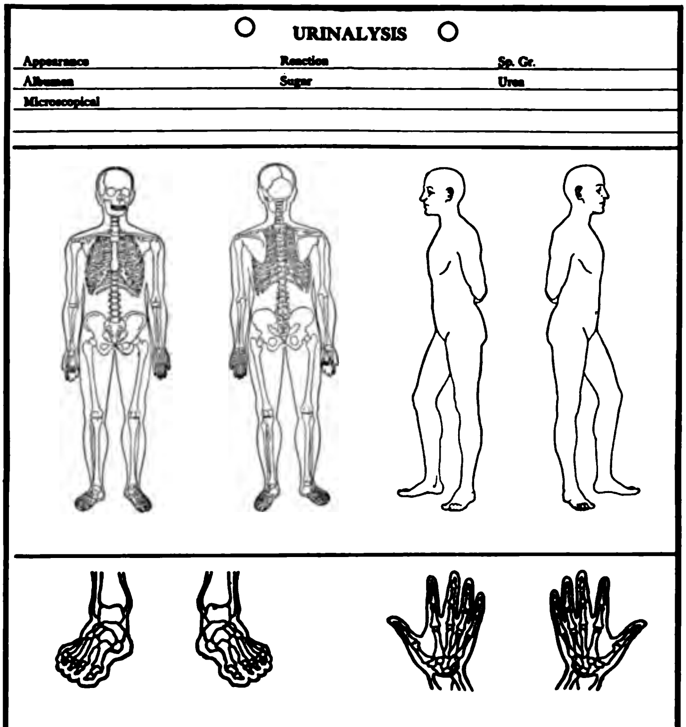
I understand the nature of the defects as found and certify my answers to be true.

Examiner .... M. D. Signed ....

FIG. 116
Physical record form for medical examination of employees, showing of what such an examination should consist.
Courtesy Bausch & Lomb Optical Company.

be reported by a foreman, or by any employee through the foreman. This given employee should then be requested to undergo a re-examination. All employees, both male

and female, should be examined once a year, as well as all new applicants for positions before being employed. All employees who are absent for one day, on account of



URINALYSIS

Appearance Reaction Sp. Gr.

Albumen Sugar Urea

Microscopical

Remarks

FIG. 117

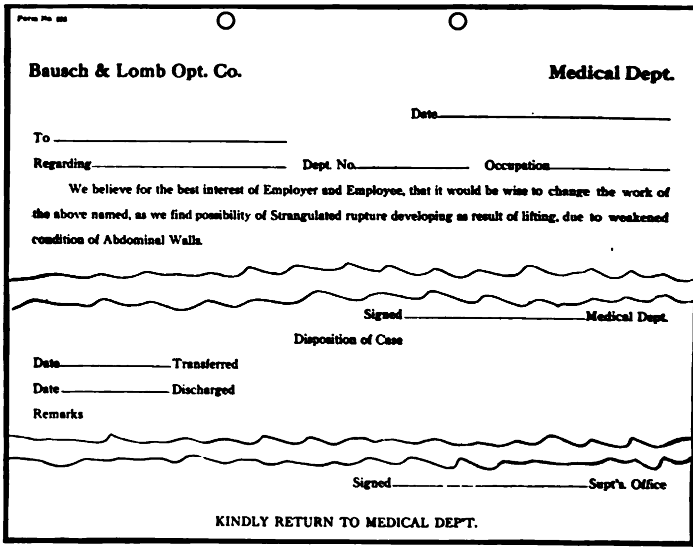
Rear of physical record form shown in Fig. 116. All injuries should be clearly indicated on these charts.

Courtesy Bausch & Lomb Optical Company.

illness, should be required to secure a "pass" from the company physician before returning to work.

The form in Fig. 116 shows of what a medical examination and record should consist. On the back of this form are

diagrams of the human body, human skeleton, and details of the bone structure of the hands and feet. (Fig. 117.) Any physical defect should be plainly marked at the correct place on these diagrams. The examination should be very thorough. This record covers all conditions affecting the health of employees which are likely to be encountered. This medical examination should be compulsory for all



Bausch & Lomb Opt. Co. Medical Dept.

Date

To

Regarding Dept. No. Occupation

We believe for the best interest of Employer and Employee, that it would be wise to change the work of the above named, as we find possibility of Strangulated rupture developing as result of lifting, due to weakened condition of Abdominal Walls.

Signed Medical Dept.

Disposition of Case

Date Transferred

Date Discharged

Remarks

Signed Supt's. Office

KINDLY RETURN TO MEDICAL DEPT.

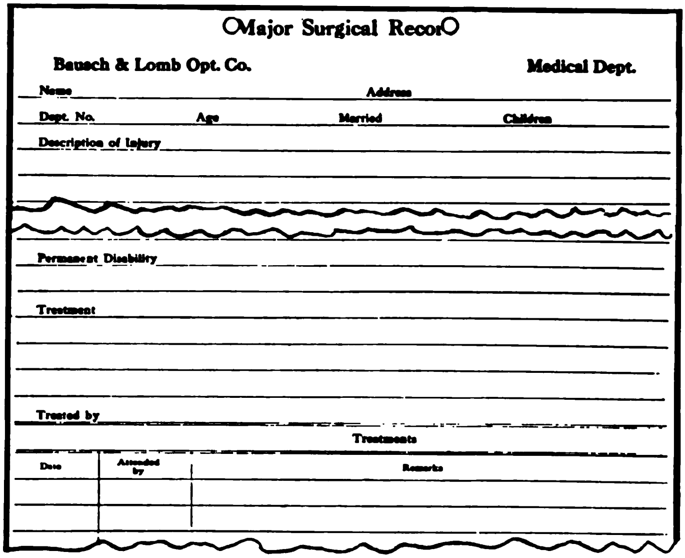
FIG. 118

Notification form to superintendent in case of hernia or rupture, advising change of work.

Courtesy Bausch & Lomb Optical Company.

employees. It does not require that a man be physically perfect, for unless he has some pronounced defect, such as tuberculosis of the lungs or a contagious disease, he is given work. The defects in the health condition should be pointed out to each employee. Advice and free treatment should be given. If working conditions are bad for a particular ailment, that employee should be transferred to another department where the work will better agree with his state of health.

The form in Fig. 118 is used as a notification to the superintendent of a case of hernia or rupture. The superintendent should then transfer the employee in question to work where the probability of his lifting heavy objects is slight. The workman should also be obliged to wear a truss to support the rupture unless he prefers to submit to an operation which will effect a permanent cure. In this con-


Major Surgical Record

Bausch & Lomb Opt. Co. Medical Dept.

Name Address

Dept. No. Age Married Children

Description of Injury

Permanent Disability

Treatment

Treated by

Treatments

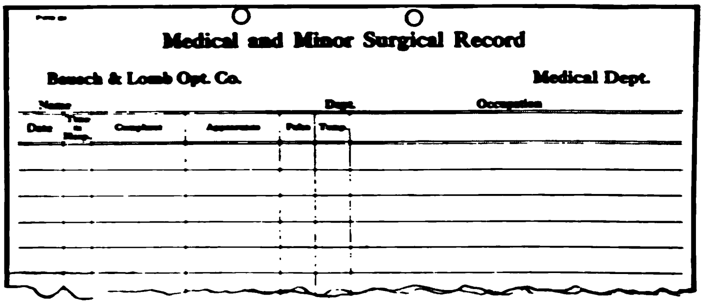
Date	Attended by	Remarks

Fig. 119
Major surgical record form.
Courtesy Bausch & Lomb Optical Company.

nection, it may be stated that a surprising number of cases of hernia have been discovered in nearly every factory where a medical examination of employees is being carried on, and that in most cases the workmen were neglecting to wear trusses. In various ways a medical examination actually saves the lives of some employees. A form, similar to the one just described, is used for heart trouble, and another for all other diseases.

The form in Fig. 119 is used as a major surgical record.

The form in Fig. 120 is used as a minor surgical record. This is used for all minor injuries and illness, such as small cuts and bruises, sore throats, nausea, etc. These forms should all be filed in one folder under the name of the employee. A complete record will thus be maintained,


Medical and Minor Surgical Record

Bausch & Lomb Opt. Co. Medical Dept.

FIG. 120
Medical and minor surgical record form.
Courtesy Bausch & Lomb Optical Company.

showing the health condition of each employee, and how each case has been treated.

The advantages of the compulsory medical examination of employees are summarized as follows:

1. The early discovery of a disease increases the possibility of cure.
2. The period of illness is shortened.
3. The chances of contagion are reduced.
4. The hygienic standards are raised.
5. The efficiency of the organization is increased.
6. The management is enabled to place employees at the kind of work for which they are fitted.
7. Illness and physical defects are pointed out to employees.
8. Employees receive advice and free treatment of illness.
9. Employees are educated in health, hygiene, and sanitation.
10. The healthy workers receive protection from those that are diseased.

Company Hospitals. — Every company of large size should maintain a hospital in the factory. It should be located in a light, sunny part of the plant where plenty of fresh air is obtainable. (Fig. 121.) The walls and floors

should be of white tile or similar material. All furniture should be enameled white. The hospital should contain an instrument cabinet, operating table, one or more beds, bed linen, medical cabinet, stretcher, wash basins, towels, sterilizing basins, electric heaters, sterilizers, a water closet, splints, tourniquets, sterilized bandages and gauzes, stools, chairs, etc. The room should be especially well lighted

FIG. 121
Operating room at hospital of Bausch & Lomb Optical Company.

and ventilated, and properly heated. Operating lamps, eye-testing apparatus, scales, electric fans and other useful accessories should be provided. A trained nurse should be employed to attend to all the minor injuries and illness, and to assist the physician in serious cases.

Visiting Nurses. — Many large companies employ visiting nurses who make periodical calls at the homes of employees for the purpose of treating the sick and instructing in all matters pertaining to health, hygiene, and sani-

tation. They do much toward educating families in methods of healthful living. The district nurse is a most welcome visitor in the homes of the sick. She is especially valuable in mining camps and other isolated communities.

Voluntary Accident Relief Plans. — Some of the larger corporations and companies have established voluntary

FIG. 122
Lunch room for employees.
Courtesy Commonwealth Steel Company.

compensation systems for employees who may become incapacitated, either temporarily or permanently, by sustaining work accidents. Compensation is also provided for dependents of workmen who may be killed while in the employ of the company. Workmen's compensation laws are now in effect in twenty-nine states, with the probability that all other states will adopt similar laws in the near future. These laws, though open to much improvement,

have done a great deal to relieve the suffering of those who are rendered physically and financially helpless by work accidents, and for dependents of those who are killed. Wherever these laws are in effect, industrial workers are, in a measure, financially compensated for injuries received during the course of their work. These laws relieve employers of the moral duty of making further provision for the welfare of employees in this particular connection.

Fig. 123
Reading room and library at the Palmerton Neighborhood House.
Courtesy New Jersey Zinc Company.

There are, however, some companies that supplement the financial aid rendered by the operation of workmen's compensation laws. If properly regulated, this assistance is highly commendable.

Pension Funds. — Pension funds have been established by a number of companies, affording relief for workers in their old age. Such a plan increases the loyalty of the working force, and enables companies to retain experienced men in their service. The following principal features of

the pension system of the United States Steel Corporation should prove of value to other companies contemplating the establishment of a pension fund:

The United States Steel and Carnegie Pension Fund was established in the year 1910, by the joint action of the United States Steel Corporation and Mr. Andrew Carnegie. Its purpose is the payment to employees of old age pensions from the income of the fund. For this purpose, the United States Steel Corporation provided $8,000,000 which, with the Carnegie Relief Fund of $4,000,000 created by Andrew Carnegie on March 12, 1901, makes a joint fund of $12,000,000. This fund is administered by a board of twelve trustees through a manager appointed by the board.

Its principal features are:

(*a*) Compulsory retirement for men at seventy years of age and for women at sixty years of age, after twenty years' service.

(*b*) Retirement at request of the employee or his employing officer after the age of sixty for men, and fifty for women, after twenty years of service.

(*c*) Retirement by reason of permanent total incapacity, after fifteen years of service.

(*d*) Pension Basis — For each year of service, 1 per cent of the average monthly earnings for the last ten years of service.

(*e*) Credit for service rendered to any of the plants of the subsidiary companies of the United States Steel Corporation or to the predecessors of such companies.

(*f*) Minimum pension, $12.00 per month; maximum pension, $100.00 per month.

Stock Subscription Plans. — In conjunction with the establishment of pension funds, some companies have formed stock subscription plans, under which shares of stock are offered to all employees upon easy and especially favorable terms, which involve benefits beyond those to the ordinary stockholders. Such a plan, if properly administered, has many apparent advantages. The stock subscription plan of the United States Steel Corporation is as follows:

Number of shares which can be subscribed for depends upon the wages of the employee, but it is relatively greater for the lower-paid men. The price of the stock is the market price, or usually a little less. Payments: Minimum, $2.00 to $3.00 per share per month for preferred, varying each year in accordance with the price of stock; $1.25 to $1.50 per share per month for common. Maximum that can be paid is 25 per cent of monthly earnings. A premium of $5.00 for preferred and $3.50 for common per annum for five years is paid on

each share of stock purchased by employees under this plan. Non-paid-up subscriptions may be canceled and the money paid in is refunded to the employee with 5 per cent interest. Premiums are not paid to employees who cancel their subscriptions, sell their stock, or leave the employ of the Company, and the forfeited or unpaid premiums are kept in a fund and divided pro rata among the remaining shareholders under this plan at the end of the five-year period.

If death occurs to an employee who has subscribed for stock and made payments under this plan, his estate receives the unpaid premiums for the full five-year period and a pro rata share of the premiums undivided at the time of death.

On December 31, 1912, more than 32,248 employees were stockholders under this plan. Their aggregate holdings amounted to more than 125,848 shares of stock. It is impossible to ascertain how many employees, in addition to those yet receiving the special benefits that continue for five years, hold stock upon which these special benefits have ceased to be paid, but it is believed that their numbers would greatly increase the figures here given.

Sociological. — The sociological work among large corporations is constantly receiving more attention. The nature and extent of what this work should embody is very well illustrated in the following weekly program of the New Jersey Zinc Company, which is carried on at one of its large mines:

WEEKLY PROGRAM — PALMERTON NEIGHBORHOOD HOUSE

Monday

A.M.	P.M.
Kindergarten, 9 to 12.	Visiting Nurses' Calls, 1 to 5.
Penny Provident Bank, 9 to 11.	Library Hours, 1 to 5.
Visiting Nurses' Hours, 9 to 12.	Boys' Chair Caning, 4 to 5.30.
	Camp Fire Circle, 4 to 5.30. (Buchra-Buchra)
	Girls' Cooking, 4 to 5.30.
	Girls' Gymnasium, 4 to 5.30.
	Penny Provident, 4 to 5.
	Foreign Girls' Cooking, 8 to 9.30.
	Dancing Class — Boys, 7.30 to 9.
	Basket Ball Practice, 7.30 to 9.
	Library Hours, 7 to 10.
	Bowling Alleys, 7 to 10.
	Hungarian Band Practice, 7.30 to 9.30.

Tuesday

A.M.

Girls' Cooking, 8 to 9.30.
Kindergarten, 9 to 12.
Penny Provident, 10 to 11.
Visiting Nurses' Calls, 9 to 12.

P.M.

Visiting Nurses' Calls, 1 to 5.
Library Hours, 1 to 5.
Camp Fire Circle, 4 to 5. (Minnehaha)
Girls' Cooking, 4 to 5.30.
Boys' Gynmasium, 4 to 5.30.
Neighborhood Visiting, 2 to 4.
Foreigners' English, 7.30 to 9.
Basket Ball Practice, 7.30 to 9.30.
Camp Fire Circle, 7.30 to 9. (Aquashicola)
Library Hours, 7 to 10.
Bowling Alleys, 7 to 10.
Palmerton Band Practice, 7.30 to 9.30.

Wednesday

A.M.

Girls' Cooking, 8 to 9.30.
Girls' Cooking, 11 to 12.15.
Home Nursing, 11 to 12.15.
Kindergarten, 9 to 12.
Penny Provident, 10 to 11.
Visiting Nurses' Calls, 9 to 11.

P.M.

Visiting Nurses' Calls, 1 to 5.
Library Hours, 1 to 5.
Neighborhood Visiting, 2 to 4.
Camp Fire Circle, 4 to 5.30. (Wenonah)
Camp Fire Cooking Class, (1st Wed.), 8 to 9.30.
Women's Fancy Cookery, (2nd Wed.), 8 to 9.30.
Camp Fire Cooking Class, (3rd Wed.), 8 to 9.30.
Foreign Mothers' Club Cooking, (4th Wed.), 8 to 9.30.
Kindergarten Mothers' Club, 8 to 9.30.
Junior Co-operative Squad Meetings, 7.30 to 9.
Library Hours, 7 to 10.
Bowling Alleys, 4 to 5, 7 to 10.
Hungarian Band Practice, 7.30 to 9.30.

Thursday

A.M.

Boys' Cooking Class, 11 to 12.15.
Boys' Carpentry Class, 11 to 12.
Kindergarten, 9 to 12.
Penny Provident, 10 to 11.
Visiting Nurses' Calls, 9 to 12.

P.M.

Visiting Nurses' Calls, 1 to 5.
Library Hours, 1 to 5.
Girls' Cooking Class, 4 to 5.30.
Neighborhood Visiting, 2 to 4.
Foreigners' English, 7.30 to 9.
Boys' Gymnasium, 7.30 to 9.
Camp Fire Circle, 8 to 9.30. (Juanita)
Library Hours, 7 to 10.
Bowling Alleys, 4 to 5, 7 to 10.
Palmerton Band Practice, 7.30 to 9.30.

Friday

A.M.	P.M.
Kindergarten, 9 to 12.	Visiting Nurses' Calls, 1 to 5.
Penny Provident, 10 to 11.	Library Hours, 1 to 5.
Visiting Nurses' Calls, 9 to 12.	Dancing, 7.30 to 9.
	Dressmaking, 8 to 9.30.
	Junior Co-operative Carpentry Class, 7 to 9.
	Library Hours, 7 to 10.
	Bowling Alleys, 2 to 5, 7 to 10.

Saturday

A.M.	P.M.
Library Hours, 9 to 12.	Visiting Nurses' Calls, 1 to 5.
Visiting Nurses' Calls, 9 to 12.	Library Hours, 1 to 5.
	Sewing School, 2.30 to 3.30.
	Penny Provident, 2.30 to 3.30.
	Library Hours, 7 to 10.30.
	Bowling Alleys, 2 to 5, 7 to 10.30.
	Open House Dance, 7 to 10.30.

Free Baths (Daily) 5.30 A.M. to 9 P.M.

Sunday

Reading Room 9 A.M. to 9 P.M.
Foreign Lodge Meetings, 2 to 4 and 7 to 9 P.M.

Special Meetings

Citizens' Co-operative Association — Third Tuesday each month, 8 P.M.
Palmerton Hospital Auxiliary — First Tuesday each month, 2.30 P.M.

Welfare work should be undertaken for two reasons; for the uplift of humanity, and as a business proposition. This work will not show actual cash returns in definite figures, but it will be reflected in increased efficiency, better health of workmen, increased loyalty to employer, and better citizenship. Welfare work is not intended to offset fair wages. It is intended to give those workers and their families education, recreation, and healthful and pleasant surroundings that cannot afford to obtain these things from outside sources. It is intended to give workmen and their families something more than the bare necessities of life.

CHAPTER XXVI

OCCUPATIONAL DISEASES

For complete information upon this subject, reference should be made to some of the modern books compiled by members of the medical profession. This subject is one that is now receiving considerable attention by physicians, employers, and welfare organizations. Its scope is too far reaching to be adequately covered in a book of this character. Some of the more important factors bearing upon the prevention of occupational diseases will, however, be briefly outlined.

Dr. W. G. Thompson of Cornell University has classified occupational diseases, injuries, harmful conditions and substances as follows:

Harmful Substances:

1. Metallic poisons
2. Toxic gases, vapors, and fumes
3. Toxic fluids (acids, alkalies, dyes, etc.)
4. Irritant dusts and fibers
   (*a*) Insoluble inorganic dusts
   (*b*) Soluble inorganic dusts
   (*c*) Organic dusts and fibers
5. Organic germs (anthrax, glanders, etc.)
6. Miscellaneous irritants

Harmful Conditions of Environment:

1. Air compression and rarefaction
2. Excessive humidity
3. Extreme heat and cold
4. Excessive light (electric, X-ray, etc.)

Occupational Injuries (Medical):

1. Injuries to nerves, muscles, and bones (strain, fatigue, cramps, faulty positions, "occupational neuroses," blows, vibrations, pressure, etc.)
2. Injuries to the eyes
3. Injuries to the ears
4. Injuries to the nose and throat
5. Injuries to the skin

Occupational Diseases of the —

1. Blood
2. Circulatory system
3. Respiratory system
4. Nervous system
5. Digestive system
6. Muscular system
7. Cutaneous system
8. Urinary system
9. Special sense organs

There is such a variety of conditions entering into the causation of occupational diseases that it is indeed a great problem to successfully reduce these diseases to a minimum.

As a protection against poisons, Dr. Fischer of Berlin has compiled the following measures:

1. Properly adapted buildings, thick walls of separation of dangerous rooms, good lighting, clean workshops, effective ventilation.
2. Apparatus adapted to its special purpose; wherever possible, closing tight in every part.
3. Appliances for accomplishing the arrest of gases and dust at their origin, their removal (by exhaust fans), rendering them innocuous, or collecting them, thus preventing them from entering the nose and mouth.
4. So far as possible, avoidance of direct contact with poisonous materials or substances, in working with, transporting, and packing them.
5. The displacement of particularly dangerous labor methods and materials by the introduction of less dangerous labor processes and materials, as well as by the employment of chemically pure materials.
6. Instruction of workers, just entering upon an occupation, concerning the properties of the poisonous substances extracted, manufactured, used, or otherwise evolved; and, wherever possible, cautionary leaflets should be placed in the hands of workers, with the repetition of this instruction at frequent intervals.
7. Posting precautionary regulations and warning signs and placards, containing admonitions for the exercise of special caution, and enjoining the observance of these measures for insuring safety.
8. Constant supervision of all dangerous employments by expert, responsible persons.
9. Employment of appropriate means for personal protection, as workclothes, caps, gloves, eye protectors, and, as necessary adjuncts, mouth and nose shields, respiratory masks, etc.
10. Practice of bodily cleanliness by the use of wash, bath, and dressing rooms, the use of special rooms for eating, separate wardrobes for work and street clothes, and frequent, non-hazardous cleansing of the clothing.
11. Immediate report of symptoms of indisposition; attention to wounds of the skin, caused by handling corrosive materials; the quick employment of

an exceptional antidote, giving promise of success, at the very first symptoms of poisoning, with the simultaneous summoning of a physician.

12. The installation of a healthy working force, capable of withstanding exposure to the poison; temporary or permanent exclusion of sick workers from dangerous departments of the industry; medical examination of the workers at suitable intervals; change of work in occupations giving rise to chronic poisoning.

13. The utmost possible reduction in the hours of labor in dangerous occupations.

A thorough medical examination of all applicants for positions is absolutely essential. This is the only method by means of which those workers who are physically unfit for these occupations can be successfully and immediately eliminated. It is important to select only those workers who have a relatively high physical resistance to industrial poisons. It is necessary to have frequent medical examinations of the workers, short working hours, and periodical changes of work to out-of-door occupations. This will afford an opportunity for employees to preserve their health and disease-resisting power, allowing the system to expel the poisons which it has gradually absorbed. If these precautions are not observed, much disease, enforced idleness, and premature death will result. Employers should strictly enforce all necessary rules and use all possible measures to preserve the health of the workers.

Employees should receive explicit instructions regarding the dangers of their work, the effects of poisoning, the precautions to be observed, and the proper first aid treatment in case of poisoning. Prominent placards, containing rules, instructions, and precautions, should be conspicuously posted in each workroom. Employees should be frequently cautioned by means of printed circulars which should be periodically distributed.

Helmets, costumes, caps, oxygen apparatus, respirators, eye protectors, gloves, and other safety devices should be employed wherever their use will afford the desired protection. Change houses, containing shower baths and wash basins, should be provided. Each worker should be assigned

an individual locker and wash basin. Employees should be required to change their clothing before entering, and immediately after leaving the workroom. They should be provided with suitable sanitary work costumes. These should be made of some washable material, and should be

FIG. 124
Workman's protective uniform for ammonia tanks.
Courtesy Eastman Kodak Company.

perfectly plain, containing no pockets or folds. Direct contact with poisonous substances should be avoided as far as possible. Employees should be required to wash and bathe before leaving the factory. Every effort should be employed to encourage cleanliness among the workers.

Employees should be forbidden to eat, drink, chew or smoke in rooms where the atmosphere is contaminated with

poisonous gases, vapors or dust. An abundance of well chosen food, prescribed by a physician, is essential in maintaining the health of the workers. They should be encouraged to engage in outdoor athletic recreation. Intoxicating liquor renders the human system peculiarly susceptible to industrial poisons; therefore, employees should be urged to abstain from its use. Those who indulge in intoxicants to any extent should not be employed.

Special attention should be given to ventilation and the destruction of poisonous dusts, gases, and vapors. This is very important. When conducted from the workroom, these poisonous elements should be chemically or physically purified, altered or destroyed before leaving the factory. Wet methods, to prevent dust formation, should be used wherever practicable. Condensation, absorption, solution, precipitation, admixing, and other chemical and physical treatments may be advantageously used, in many instances, in the destruction of poisons. By-products are often thus obtained which form a source of profit.

Employers should realize the importance of providing and maintaining safe and sanitary conditions; otherwise, the working force will be demolished through illness and disease, making it necessary to constantly add new inexperienced workers to the organization. This would entail a large financial loss to the company through inefficiency and waste, as well as much misery among workers and their families by enforced unemployment.

CHAPTER XXVII

FIRST AID TO THE INJURED

FIRST aid treatment to the injured, if correctly administered, does much toward saving lives and minimizing suffering. Few realize how great a service a workman, educated and trained in first aid methods, can render to an injured fellow-workman. He may save his life, and at least he will do a great deal toward making possible a quick recovery. The only way in which workmen can receive adequate first aid instruction and practice is through the organization of a first aid staff in each factory. Classes of workmen from each department, including foremen, should be given this instruction by a physician. A sufficient number of men should be so trained for this work that there will always be several men in each department who have a good knowledge of first aid methods. These classes should meet periodically, every week or so, until they have received thorough instruction and training.

It is also advisable to instruct all employees, through illustrated talks, lectures, and pamphlets, in the fundamental principles of first aid, health, sanitation, and hygiene. It is surprising how ignorant is a large majority of workmen concerning these subjects. A great deal can be accomplished toward educating employees by making the lectures interesting. These lectures should be held at least once a month. All employees should be encouraged to attend. Lectures may be followed by some kind of an entertainment, which will tend to arouse more than a common interest among the workers.

First Aid Organization. — The purpose of a first aid organization should be to instruct and train employees to assist

those who may be injured or rendered helpless, to promote good fellowship among its members and the other workmen, and to enlist individual and public interest in the social betterment and public health of all.

The officers should consist of a chairman, secretary, treasurer, and medical supervisor. Foremen should be appointed as captains of squads, consisting of six employees, including a patient. These squads should be instructed and drilled every week in first aid methods. The drills and instructions should cover all possible general classes of injuries.

First aid treatment should always be supplemented by examination and treatment by a physician. This is essential, even though the injury seems trivial. Often much harm is done by well intended, but unskilled treatment by foremen or fellow-workmen, who have not an adequate knowledge of first aid methods.

General Instructions. — General instructions, briefly describing what to do in an emergency, should be conspicuously placed upon bulletin boards in each room. The Norton Company uses the following first aid instructions:

FIRST AID

IN CASES OF

ILLNESS OR ACCIDENT

INSTRUCTIONS

First Duties:

1. Notify Doctor. (Names, addresses and telephone numbers of at least two doctors.)
2. Telephone for ambulance if necessary. (Telephone number.)
3. Prepare bowl of hot water, soap, scrubbing brush, and gauze for cases of cuts and bruises.
4. Prepare splints in cases of severe injuries.
5. When patient arrives, proceed at once to follow directions given by doctor for that type of injury.

For Burns and Scalds:

1. Remove all clothing from injured part.
2. Immerse extremity in large pail or foot tub containing sat. sol. bicarbonate of soda.

3. **Parts which cannot be immersed should be covered with soft cotton cloth soaked in carron oil.**
4. **Slight burns should be powdered with compound stearate of zinc powder.**
5. **If much shock, give teaspoonful of aromatic spts. of ammonia in one-half glass of water; or, one tablespoonful of Brandy in one-half glass of water.**
6. **If pain is unbearable give ¼ grain of morphine.**

For Fainting and Sudden Sickness:

1. Get patient on back with head lower than heels.
2. Give one teaspoonful of aromatic spts. of ammonia in one-half glass of water.
3. Put towel, soaked in cold water, to head.

For Fractures and Dislocations:

1. Remove clothes about injured part by cutting.
2. Put injured part at rest on splint, after applying a dressing of gauze soaked (sopping wet) in a mixture of lead and opium.
3. Let patient lie down.
4. If pain is very severe, give ¼ grain of morphine.

For Major Injuries (Fractures with laceration, etc.):

1. Remove clothes around injured part by cutting.
2. Wrap all exposed parts, *except injury*, in blanket.
3. Put patient on his back.
4. Cover with blanket.
5. Wash around wound thoroughly with soap and water, as in minor injuries.
6. Put on large pad of gauze soaked in solution of bichloride of mercury (1–1000).
7. If patient is pale or white, give one teaspoonful of aromatic spts. of ammonia in one-half glass of water.
8. If much pain, give ¼ grain of morphine.

For Minor Injuries (Crushing or cutting injuries involving fingers, hand, foot or small areas):

1. Clean thoroughly by washing part in hot water with green soap, using scrubbing brush for area around wound, and gauze for the wound itself.

   DO THIS FIVE MINUTES BY WATCH.[1]
2. Wash off in turpentine or benzine. (NOT IMMERSING.)
3. Soak in bichloride of mercury (1–1000) for THREE MINUTES BY WATCH or until doctor arrives. If doctor is not required, apply sterile gauze, bandage and finger splint.

   DO NOT TRY TO STOP FLOW OF BLOOD UNLESS VERY SEVERE; THE HOT BICHLORIDE SOAK AND BANDAGE WILL STOP IT.

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[1] Attention should be called to the fact that it is often dangerous to wash a wound, except when done by a physician, as germs may be washed further into the wound and remain there. A compress soaked in tincture of iodine is recommended, without washing, provided the wound can be treated by a physician within a short time.

Equipment. — In plants of any size the management should provide a suitable hospital room, located in a light, sunny part of the factory where plenty of fresh air may be obtained. This hospital room should be equipped as

Fig. 125
First aid kit.
Courtesy Johnson & Johnson

described under "Hospital" in the chapter on "Welfare Work."

The following equipment, exclusive of the hospital supplies, is needed in any medium size factory. This equipment should, of course, be increased according to the size of the plant:

Several First Aid Cabinets containing:
- 12 triangular bandages
- 12 medium size safety pins
- 6 packages of gauze (both plain and picric)
- 6 light wood splints — $3\frac{1}{2}$ inches wide and 18 inches long
- 12 roller bandages — assorted sizes
- 2 tourniquets
- 2 rolls of cotton — plain and absorbent
- Several bottles containing tincture of iodine, aromatic spts. of ammonia, boracic acid, etc.:
- 2 tubes of burn ointment

also:
- 1 standard stretcher (U. S. Army regulation)

2 blankets
6 wooden splints for legs and back fractures
2 sets of first aid charts

The Brooklyn Rapid Transit Company uses a novel type of First Aid case which has the following advantages:

1. It is easily portable, being made of leather, 12 inches in height, 17½ inches long, and 8 inches in breadth, having a handle and a catch and lock like a suitcase.

2. The solutions most largely employed, namely, carron oil, boracic acid, and lead and opium solution, are contained in thermos bottles, so that they are unaffected by temperature no matter where the case is used.

3. All dressings are put up in individual packages, thereby practically eliminating the chances of using an infected dressing.

4. The number of articles which a layman is required to use is reduced to a minimum.

5. A flap, separating the two halves of the case, contains on one side a list of the articles therein, and on the other side a set of instructions with respect to the use of the case in the treatment of the classes of injuries in which it will more commonly be employed.

6. The case contains a sealed compartment to be opened only when a physician is called to give emergency treatment. This compartment contains a pocket kit of surgical instruments, a hypodermic syringe and solution of cocaine, catgut, needles for closing wounds, plaster of Paris bandage, and splints.

One person should be held responsible for the proper upkeep of the first aid equipment. It should never be allowed to become depleted in any way. If the factory be a large one, this first aid equipment should be located at several convenient points. First aid equipment should also be distributed at different points about a mine. Every engineering office on construction work and every quarry should be similarly equipped. The addresses and telephone numbers of several physicians should be conspicuously printed on placards attached to telephones in each room, so that a physician can be quickly summoned in an emergency.

Eye Injuries. — The human eye is the most valuable sense organ of the body. It is, however, the most frequently neglected and unprotected. If the eyes are injured by molten metal, strong acids and alkalies, or chemicals, there is little or no relief. The result is usually total

blindness. No less serious accidents happen from flying chips of steel, emery and other foreign bodies. It is, therefore, of the utmost importance that the eyes be protected with suitable goggles. Each workman should be supplied with an individual pair. Otherwise, if goggles are promiscuously interchanged among workmen, infection from the eyes of one workman may be spread, through the medium of the goggles, to the eyes of many other employees.

When a workman attempts to remove a foreign body from a fellow-workman's eye, he usually employs a toothpick, pin, match, jackknife, or some other dangerous and unsanitary instrument. The usual result is that the eye becomes infected. Again, if foreign bodies are not skilfully removed by a physician or an oculist, the delicate surface of the eye may be torn or abraded. This will cause inflammation and ulceration, eventually resulting in a complete loss of vision. Delay is dangerous, and may result in a condition which the physician or the oculist will be unable to cure. The finest instruments and the best of light are necessary to remove fine particles of steel, emery and similar substances, without leaving a scar. If goggles are not worn in grinding or chipping, pieces continually become lodged in the eyes. They may thus in time become so scarred, if they do not earlier become infected, that the vision will be ultimately lost.

The eyes may be injured by flying chips of stone, brick, and steel; by chips and dust from emery wheels and other grinding, buffing and polishing wheels; by spattered molten metal, ammonia and other chemicals; by dust, gas and powder explosions, by electrical flashes, by exposure to the electrical arc used in welding, by continued exposure of the eyes to air laden with dust and fumes, and by other objects forcibly entering the eyes.

Flashed Eyes. — Electrical flashes, though of momentary duration, develop almost instantaneously a great amount of heat. This produces painful burns on the unprotected eyes. Also, continued exposure to the rays of the

electric arc used in welding will cause similar burns, even though the victim is not near enough to feel any intensity of heat. Such burns do not usually become apparent until several hours after the exposure. The serious effect of flashed eyes is caused by the ultra-violet rays which are present in the electric arc. To properly protect the eyes, operators should wear helmets with openings for the vision filled with red and blue glass.

Symptoms. — Eyes which have been exposed to electrical flashes become very red. Intense pain manifests itself. There is an aversion to light, and a copious secretion of tears. Often the eyebrows and eyelashes are singed, the eyes being filled with charred particles of hair and skin débris. In the more severe cases, a zone of red appears about the cornea. If the heat is sufficient, the superficial layers of the cornea are coagulated.

Treatment. — THE EYES SHOULD BE TREATED ONLY BY A PHYSICIAN, NURSE, OR AN OCULIST.

Asphyxiation or Suffocation. — (See Appendix.)

Resuscitation by Artificial Respiration. — (See Appendix.)

Electric Shock. — Shocks from electricity are very common, especially in mines and on line work. They frequently occur in and about manufacturing plants, and even in the household.

Symptoms. — The symptoms are: sudden loss of consciousness; absence of respiration; or, if present, very light and irregular, and may not be noticeable; very weak pulse; and body burns at the point of contact.

Breaking the Circuit. — (See Appendix.)

Treatment. — Cases of asphyxia from electric shock should be treated as described under "Resuscitation by Artificial Respiration." Electrical burns should be treated as described under "Burns."

Infection. — Infection is responsible for a great amount of grief and suffering. It gives rise to much sickness, makes many amputations necessary, and is the cause of a great many deaths.

Infection is always caused by virulent germs or bacteria. The germs are always lurking upon nearly all objects, in the ground, on the body, in water and impure air. They thrive in dark, moist places. Sunlight and dryness tend to kill them. When they are confined in a small place, their own poison, which they give off, kills them. They may also be starved from a lack of proper food. There are countless varieties of germs, each requiring a special food, warmth, and a proper breeding place.

These microscopic organisms, some being so small that they cannot even be detected with the highest power microscope, multiply very rapidly. They breed, on the average, every half hour. In breeding, one of these minute organisms will split itself to form two organisms, and so on. This process is repeated over and over again. In the course of one day, these organisms may produce millions of descendants. It may be readily seen that, at this rate of multiplication, there is need of quickly and positively destroying these harmful organisms at the start. As they grow, they evolve poisonous substances called toxins. These toxins may simply act as irritants, or they may be virulent enough to destroy all the tissues of the body with which they come in contact. In many cases, these bacteria are spread broadcast through the body by means of the blood, after having gained entrance through a cut, wound, abrasion, or by some other means. They thus poison every part of the body which they touch, causing blood poisoning, or other diseases. Bacteria also gain entrance to the body through the respiratory and digestive systems. They produce headache and fever. They often cause pus to form in the wound or its vicinity, which prevents the wound from healing. There is a great variety of germs, which cause blood poisoning, one of which causes lockjaw.

Symptoms. — The first sign of infection is pain or irritation, heat, redness of the skin, and swelling. The formation of pus is attended with agony, increased temperature, and insomnia due to the pain.

Treatment. — If the wound thus becomes infected, it should receive special attention at once. Every cut, abrasion, bruise, wound, and even scratches, should immediately be washed and cleansed, treated with a disinfectant, and bound up to keep out all dirt.[1] This should be done in all cases, NO MATTER HOW SLIGHT THE ABRASION MAY BE. A tiny pin scratch may easily develop into a dangerous case of blood poisoning, which may eventually result in death. Infection is almost always the result of neglecting to thoroughly cleanse and disinfect the wound, protecting it with a light bandage to keep out dust, containing more bacteria, or other unclean things from coming in contact with it.

A disinfectant or germicide is an agent that is fatal to germs and to their spores and eggs. The process of destruction of the germs in clothing, excreta, wounds, objects, air, and water is known as disinfection. The disinfection of dressings and surgical instruments is called sterilization.

There are hundreds of thousands of cases of blood poisoning in this country each year. Many of these cases could have been easily avoided by immediate and proper attention to all cuts, wounds, and bruises. The matter of immediately cleansing, disinfecting and bandaging cuts, wounds, and bruises, although it may seem trifling at the time, is an EXTREMELY IMPORTANT DETAIL.

Hemorrhage. — Hemorrhage means loss of blood. It is usually caused by an injury which ruptures blood vessels, or by a diseased condition of blood vessels. The danger of hemorrhage depends upon the amount of blood lost, and the rapidity with which it escapes. The loss of one-third of the blood in the body is usually fatal.

There are three kinds of hemorrhage; namely, arterial, capillary, and venous. Arterial hemorrhage is the most dangerous and difficult to control.

Control of Hemorrhage. — Hemorrhage may be controlled by pressure, position, heat or cold, torsion, or ligation or tying of the blood vessel. The only methods which can

[1] See foot note page 405.

usually be employed are compression and position. Compression is more important. It should be applied by the fingers, compresses, tourniquets, or constricting bands, such as a handkerchief, belt strap, suspenders or strips of cloth.

In case of arterial hemorrhage, the blood gushes forth in a bright red stream. The pressure must be applied between the wound and the heart. In case of capillary hemorrhage, the blood oozes away slowly, and is of a brick red color. The bleeding is easily controlled by directly applying a clean compress of gauze to the injury. In venous hemmorrhage, the blood is a dark red color, and discharges in a steady stream. The compression should be made on the side of the wound away from the heart. Usually the bleeding can be controlled by directly applying a large compress of sterile gauze over the bleeding part.

Elevation of the bleeding parts always aids in controlling the flow of blood. As soon as the bleeding has been stopped, the patient should be treated for shock.

Shock. — Shock is a sudden depression of the vital powers, arising from an injury, or a profound emotion, acting upon the nerve centers, producing exhaustion.

Symptoms. — The symptoms of shock are: subnormal temperature; and irregular, weak and rapid pulse; a cold, clammy, pale, and profusely perspiring skin; and irregular breathing. The person affected usually remains conscious, and will usually answer when spoken to, but is stupid and indifferent, lying with partly closed lids. Always be sure that there is no concealed hemorrhage.

Treatment. — Lower the patient's head, wrap him in hot blankets, and keep him quite warm. Administer an ordinary stimulant, such as hot black coffee. It should be as hot as the patient can sip it. Give half-teaspoonful doses of aromatic spirits of ammonia every twenty or thirty minutes. Small doses of whisky or brandy may be given if there is no hemorrhage. One or two teaspoonfuls every fifteen or twenty minutes will aid the patient until the

doctor arrives. Inhalation of oxygen is also an aid. Artificial respiration may be necessary in some cases. Hot applications over the heart and spine should be used. A doctor should be summoned in all possible haste when the condition of the victim is discovered.

Contusions or Bruises. — A contusion or bruise is an injury caused by the application of blunt force, the skin being unbroken. Blood collects in the tissues under the skin covering the bruised area. In many deep contusions the skin is not damaged, but over bone the skin is apt to be injured. If a large blood vessel is ruptured, much blood gathers in the tissues under the skin, causing great swelling and discoloration.

Symptoms. — The symptoms of contusions or bruises are: swelling, tenderness, numbness, followed by aching pain. Discoloration usually occurs quickly, especially in surface contusions. It may also occur in deeper ones.

Treatment. — Elevate the injured part, bandaging it tightly to arrest the bleeding and control the swelling. Apply an ice bag, or towels which have been wrung out in ice water. In case of the aged or weak, make hot applications instead of cold.

Wounds. — A wound is a break or division of the tissues, usually produced by sudden force. Wounds are classified as follows: Incised, made by some sharp instrument or object; contused, caused by a blunt, flat or rough object; lacerated, caused by a tearing force, such as by the teeth or claws of animals; and punctured, caused by some pointed object.

Symptoms. — The symptoms are pain, bleeding, and gaping or retracted edges of the skin and tissues.

Treatment. — First, thoroughly wash out and clean the wound at once. Then arrest the bleeding by one of the methods previously described, and apply some disinfectant. Then cover the wound with a piece of sterilized gauze, or with clean linen which has been boiled. The gauze should be firmly held in place by a bandage. The wound must

be covered to keep it clean and free from subsequent infection.

Fractures. — A fracture is a break in a bone caused by direct or indirect violence. Fractures constitute an important class of injuries, not only because they render the victim a cripple for the time being, but because the further usefulness of the limb depends upon correct diagnosis of the fracture, and upon its immediate and future treatment. Ignorance and carelessness in handling a fracture at the start frequently render the victim an invalid or cripple for life.

The main classes of fractures are: complete, incomplete, simple, and compound. In case of an incomplete fracture, the bone is not entirely broken. In case of a complete fracture, the bone is completely broken in two. In case of a simple fracture, the bone does not protrude through the skin; that is, the skin around the fracture is not injured. In case of a compound fracture, either one or both of the broken ends protrude through the skin, or else the force which causes the fracture cuts or tears the flesh to the bone. A compound fracture is nearly always accompanied by loss of blood, and a nervous shock of varying severity.

Symptoms. — The symptoms of fracture are: pain, swelling, discoloration, abnormal motion, loss of power, and the grating of the parts of the bone upon each other.

Treatment. — In examining the fracture, great gentleness should be exercised in handling the injured parts. The limb should be handled as little as possible. If the nature of the injury is in doubt, it should be treated as a fracture until the physician arrives. NEVER ALLOW A PERSON SUFFERING FROM A FRACTURE TO BE MOVED, if possible, until the limb is properly supported by splints. To treat a fracture, draw the limb to the natural position, securely binding it by means of splints and bandages. The limb should be supported in any easy and natural position.

Dislocations. — A dislocation is a complete separation

or displacement of the members of a joint, usually caused by direct violence, but may be produced by indirect violence or sudden muscular contraction. Dislocations are always painful, because they are usually accompanied by wrenching and tearing of the ligaments about the joint. They are sometimes complicated by a rupture of the muscles, and by injuries to surrounding vessels and nerves.

Dislocations are classed as simple, compound, and complicated. In case of a simple dislocation, the articular ends are separated without injury to the surrounding tissues. In case of a compound dislocation, the ligaments around the joint are torn. In case of a complicated dislocation, the surrounding muscles, vessels, and nerves are injured.

Symptoms. — The symptoms of dislocation are: pain, swelling, discoloration, and rigidity. The natural position the limb is changed, and the length is increased or decreased.

Treatment. — Restore the bone to the normal position and hold it in place. To properly reduce the dislocation, some surgical skill and knowledge of the anatomy of the joint are required. The bone should be held in position until the arrival of a physician. No attempt should be made to reduce any dislocations, except those of the jaw or fingers, until the doctor arrives.

Sprains. — A sprain is the wrenching or twisting of a joint, which tears and stretches the surrounding ligaments, and sometimes the soft parts. Sprains are important injuries, and should receive immediate treatment. Permanent disability sometimes follows failure to give the injury proper treatment. Sprains are often more serious than fractures.

Symptoms. — The symptoms are: severe pain, swelling, discoloration, and often partial or complete loss of power of the part affected.

Treatment. — Allow the patient to rest. Elevate the injured part, fastening it in the proper place by splints and a roller bandage, or with adhesive plaster. Make hot applications with a towel which has been wrung out in

hot water. Never allow the patient to rest any of his weight on the injured part, nor attempt to use it in any way. A serious sprain will remain weak for a long time; consequently, the injured parts should be favored until the sprain has entirely healed.

Strains.— A strain is the wrenching or tearing of a muscle or tendon, usually caused by violent exertion, such as lifting heavy objects, or by sudden, unexpected movements.

Symptoms. — The symptoms of strain are: sudden sharp pain, and sudden weakness of the part affected. Later, the pain becomes dull, and the weakness more marked. Sometimes the patient cannot use the injured part at all.

Treatment. — Allow the patient to rest. Tightly bandage the injured part. It is sometimes necessary to prevent movement of the injured part by the use of splints. Strapping the muscles supports them, and relieves the pain.

Hernia or Rupture. — Hernia or rupture is the tearing apart, in a weak place, of the abdominal muscles containing the intestines, forcing the intestines through the abdominal wall. There are two naturally weak places in the abdominal wall, one on each side, just above the groin. Hernia is usually caused by lifting heavy objects, or by sudden violent strains.

Symptoms. — The symptoms of hernia or rupture are: pain and sudden weakness, as in strains. A large or small lump, caused by the intestines being partly forced through the abdominal wall, may be observed when the patient coughs or strains. When he stops coughing or straining the muscles return to their normal position. A rupture which has just been started can only be discovered by a physician.

Treatment. — If a rupture is not cared for, it soon becomes larger. The rupture can be prevented from increasing in size by wearing a truss. It can only be permanently cured by an operation, which is not at all serious. This will make the person as strong as ever. No man should

be allowed to do heavy lifting until after he has been cured by an operation. Otherwise, the rupture will become much worse. It may become so serious that the intestines will be pushed so far through the abdominal wall that they cannot return to their normal position. Anyone suffering from hernia or rupture should undergo an operation.

Burns and Scalds. — Burns are caused by the exposure of the body to intense heat, such as caused by fire, molten metal, certain chemicals, electricity, or explosions of gas or powder; whereas, scalds are produced by moist heat such as the heat from boiling water or steam.

Burns are divided into three classes, according to depth. A first degree burn is simply a scorching and reddening of the outer layer of the skin. A second degree burn destroys the entire thickness of the skin. A third degree burn destroys, not only the entire thickness of the skin, but also the tissue beneath, sometimes entirely to the bone.

Symptoms. — In case of a first degree burn, the symptoms are severe burning pain, reddening of the skin, and the formation of blisters. In case of a second degree burn the symptoms are excruciating pain and destruction of the skin. In case of a third degree burn the victim suffers intense pain, the entire skin and the tissue beneath being destroyed. In case of severe burns, the patient suffers from shock.

Treatment. — Remove the clothing, if it covers the burned part. Exclude the air as quickly as possible from the burned surface with some clean, soothing covering, such as picric acid gauze. This is simply plain gauze saturated in a solution of picric acid (one-half teaspoonful of picric acid to one pint of water.) Place a layer of absorbent cotton over the gauze. Then apply a bandage to hold it in place.

"Unguentine" is excellent for burns. This is a soothing and antiseptic salve contained in metal tubes which may be bought at any drug store. Vaseline, sweet oil, olive oil, and balsam are all good dressings. Bicarbonate of soda

(cooking soda — half a cupful or more in a basin of luke-warm water) makes a good solution in which to soak the burned part for half an hour, or until the pain is relieved. This treatment should be supplemented with an application of sweet oil and careful bandaging. In case of bad burns, remove all clothing and place the patient in bed. Cover all burned parts with cloths soaked in bicarbonate solution. Send for the nearest doctor at once. Also immediately treat the patient for shock.

The blisters which later appear should be opened by the doctor, otherwise blood poisoning may result from infection.

Poisoning. — It is often difficult to ascertain the cause and nature of sudden poisoning, and to find out what the victim has swallowed. He may be able to impart this information, otherwise, it is necessary to quickly look around for bottles, packets, papers, and other containers.

Poisons are divided into two main classes; namely, irritants and narcotics.

Irritants are those which are so strong that they burn, partially or wholly corroding and destroying the tissues in the mouth, gullet, stomach, and other parts with which they come in contact. The most common of this class are sulphuric acid, strong alkalies (ammonia, potash, soda), nitric acid, hydrochloric acid, spirits of salts, cantharides, oxalic acid, and phosphorus.

Narcotics are those poisons which directly affect the nervous system, causing stupor. The most common of these are laudanum, morphine, strychnine, prussic acid, chloral, cyanide, and belladonna.

Symptoms of Irritant Poisoning. — The symptoms of irritant poisoning are intense pain in the region of the chest and stomach, whitened lips and mouth which are normally red, burning or staining of the skin or clothing, and short, quickened breathing.

Treatment. — Make the victim drink castor or sweet oil, whites of raw eggs, milk, flour and water, soap suds, or magnesia and water. The patient should be given nothing to

induce vomiting, as this will increase the irritation and damage already done. The exception to this rule is where the patient is known to have swallowed phosphorus. In this case, make the patient drink two teaspoonfuls of mustard, mixed with a large glass of water, or some other safe and handy substance to produce vomiting.

Symptoms of Narcotic Poisoning. — The symptoms of narcotic poisoning are drowsiness and limpness, and a cold, damp skin. In case of laudanum poisoning, the pupil of the eye becomes very small, while in case of poisoning by belladonna, the eye is nearly all pupil.

Treatment. — Give mustard and water in large drinks to provoke vomiting. A tablespoonful of common salt in a glass of warm water will do. If these methods fail to produce vomiting make the patient vomit by thrusting a finger down his throat, or tickling his throat with a feather. Make him drink plenty of strong coffee after vomiting. Keep him awake at all costs by making him walk and shouting at him. Never let him go to sleep, as he will never awake. If he cannot be aroused, constantly give artificial respiration. Make him inhale smelling salts or ammonia.

The two main things to remember are to thoroughly empty the patient's stomach and to keep him awake. (For table of poisons, symptoms, and antidotes see Appendix.)

Fainting. — Fainting occurs when a person sinks in an exhausted and insensible condition, remaining quiet without any contortion of the body.

Treatment. — Place the patient on his back, loosening all tight clothing. Give him plenty of fresh air. Dash cold water on his face and neck. Allow the victim to smell ammonia or smelling salts. Give the patient a little water to drink when he becomes conscious.

Epileptic Fits. — Epileptic fits occur where the victim falls suddenly without any apparent cause, throws his arms and legs about violently, twists his head, and froths at the mouth.

Treatment. — Place the patient on his back on something soft, as a mattress or a couch. Loosen all tight clothing. Hold the patient to prevent him from injuring himself during the violent convulsions. Place a small rolled bandage between the teeth to prevent the victim from biting his tongue.

Apoplectic Fits. — Apoplectic fits occur where the victim falls suddenly in an unconscious condition. The face is usually red and flushed. The patient breathes heavily in a snorting or puffing manner. The pupils of the eyes are unequal in size, and the limbs on one side of the body are usually paralyzed.

Treatment. — Loosen all tight clothing. Raise the head and shoulders, placing a rolled coat under the head. Dash cold water on the head, giving the patient plenty of fresh air.

Sunstroke. — When a person suffers from sunstroke, he falls suddenly with a flushed face. There may be convulsions. The head and neck are very hot to the touch.

Treatment. — Carry the victim at once to the shade. Loosen all tight clothing. Raise the head and shoulders, dashing cold water on the head and chest. Use ice if it can be obtained. Fan the patient, if he can get but little air.

APPENDIX

Asphyxiation or Suffocation [1]

Asphyxiation arises when the body is deprived of air or oxygen. It is caused by the presence of gases which do not support life when inhaled, by certain drugs, by electric shock, by heavy blows on certain parts of the body, (such as a blow on the solar-plexus, jaw, neck or head), and by apparent drowning.

Asphyxiation by gases may be caused by illuminating gas, carbon monoxide, carbon dioxide, nitrogen, ammonia fumes, gasolene fumes, gases from blast furnaces and household stoves, gases in mines, gases from gas producers, fumes from molten brass, elements freed from their compounds, such as chlorine, bromine and similar gases, sulphur dioxide, formaldehyde, various non-respirable fumes and gases in different chemical processes, exclusion of fresh air as in a bank vault, confined air as in the compartments of ships, sewer gas, smoke, chloroform and ether in excess, and by other gases and fumes.

Asphyxiation may also be caused by something that blocks the windpipe, preventing air from entering the lungs.

Resuscitation by Artificial Respiration [1]

Suspended animation, due to the above enumerated causes, should at once receive treatment by artificial respiration. There should be no delay. Every second counts when a person is in this condition. Loss of a few moments may mean the loss of a life. Quickly get the patient in fresh air; do not stop to loosen his clothing, but apply artificial respiration at once. Rapidly feel in his mouth and throat, removing any tobacco, false teeth, gum, and other foreign substances. Lose no time in sending someone to summon a physician.

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[1] The subject matter under these headings is an extract from a book on "Electrical Injuries" by Dr. C. A. Lauffer, Medical Director, Westinghouse Electric and Mfg. Co., published by John Wiley & Sons, New York.

Artificial respiration must be perseveringly continued if the life of the victim is to be saved. Even if the victim has apparently been dead for some time, efforts to restore life should be unceasingly applied for a long while. Although no radial wrist pulse may be felt, the heart may still be feebly beating.

There are several methods of giving artificial respiration, but only one method, the best one, is described here, for the reason that it is better to learn one method thoroughly than to have an inadequate knowledge of several different methods which would result in confusion and failure in an emergency.

The Shaefer or Prone Pressure Method of artificial respiration will now be described.

The three essentials of this method to be remembered and practiced, in anticipation of an emergency, are as follows:

FIG. 126
Shaefer method of artificial respiration, — inspiration.

1. Lay the victim on his stomach, turning face to one side, so that the mouth and nose are free for breathing. Let an assistant draw forward the victim's tongue.

2. Straddle the patient's hips, facing his head. Rest the palms of your hands on his loins (the muscles of the small of the back), with your fingers spread over his lowest ribs.

3. Gradually throw the weight of your body and shoulders forward so as to bring your weight heavily on the lower ribs of the patient by means of your hands. (Fig. 127.) The operator's downward pressure should last about three seconds. The pressure should be light at first, and gradually increased without violence up to the end of the three seconds. The pressure and rate should be uniform in each repetition. Sudden thrusts and irregularities do not conform to natural respiration. The operator's arms should be kept rigid and not bent at the elbows. The weight should all come from the shoulders, pressure on the ribs being made with the heel of the hand. After the duration of three seconds, immediately spring backward to relieve the pressure, returning to the position shown in Fig. 126.

Repeat this operation regularly from twelve to fifteen times per minute, swinging backward and forward, completing a single respiration in four or five seconds. There is danger of exceeding a maximum of sixteen respirations per minute, therefore an assistant should regulate the rate of respiration with his watch. If the operator is alone, he can fairly closely judge the time by his own regular breathing.

As soon as artificial respiration has been started, an assistant should loosen any tight clothing about the patient's neck, chest, and waist. Artificial respiration should be continued without interruption until natural breathing is restored. If necessary, the operation should be continued for TWO HOURS OR LONGER, or until a physician arrives to take charge. If natural breathing stops, after having been restored, again continue artificial respiration.

FIG. 127
Shaefer method of artificial respiration, — expiration.

Do not put any liquid in the patient's mouth until he is fully conscious. Give him plenty of fresh air, but keep him warm. Send for the nearest doctor as soon as the accident is discovered.

This method is applicable in cases of asphyxiation by electric shock, drowning, gas poisoning, and by any other cause. The four points to be especially remembered in connection with this method are:

1. Position of patient.
2. Posture of operator.
3. Mode of operation.
4. Rate per minute, and duration of each respiration.

A cloth, saturated with aromatic spirits of ammonia, when held near the nose, is more useful than oxygen.

Do not allow the patient to sit up or stand until he has fully recovered, as a second collapse may result in heart failure, all subsequent efforts at artificial respiration being unavailing. The patient should be watched for some time after recovering.

In all cases of insufficient respiration — that is, when the patient breathes regularly, but very slowly, artificial respiration should not be given. If possible, nature should unaided be allowed to restore the natural rate of breathing.

It is often advantageous to allow the patient to breathe pure oxygen. This may be applied from a cylinder containing this gas under pressure, a breathing bag, connecting tubes, face mask, and inspiratory and expiratory valves being used. The oxygen may also be supplied by an oxygen generator. If this is done, no reducing valve will be necessary. In case the patient cannot breathe, when an oxygen generator is being used, artificial respiration should be administered in order to cause the oxygen to enter and expire from the lungs at regular intervals. This, of course, is not necessary where pulmotors are used.

In cases of poisoning by carbon monoxide, in mines or elsewhere, the use of oxygen is important. This gives the blood an excess of oxygen which counteracts the injurious effects of this gas.

While pulmotors are a valuable aid in artificial respiration, these or other appliances can never supersede manual methods of resuscitation. No reliance can be placed upon any apparatus that cannot be carried on the person, nor upon any apparatus that is unready for instant use. It therefore behooves superintendents and foremen to learn this manual method of giving artificial respiration. They should so train and educate the men under them in this method that they will be able to render invaluable aid in an emergency.

A working knowledge of one good method of giving artificial respiration is essential in every walk of life. One's failure to learn a method of giving artificial respiration may be responsible for the needless loss of a life. Each man should be taught to think out beforehand what to do and how to do it, so that he can act quickly in an emergency, doing the proper thing at the right time. This is especially true in cases of possible electrical injuries. The locations of switches, circuit-breakers, and methods of breaking the circuit should be determined in the minds of each workman before an accident of this nature can occur. A little forethought in this connection will result in fewer serious injuries and fatalities.

Breaking the Circuit [1]

Where a victim is unable to release his grasp on a circuit conductor, the greatest care, and at the same time all possible speed, must be exercised to save the victim and also prevent injury to the rescuer.

If there is a circuit-breaker near at hand, the current should be shut off at once; if none, remove the victim by means of any dry non-conductor, such as a dry stick of wood, or long wooden handle of a tool, such as a shovel or pick. Take great care not to let any metal part come near the conductor or victim. Either push or roll the body aside, or shove away the conductor. The rescuer can stand on a real dry wooden or concrete floor and pull the victim away by his clothing without danger to himself, but the floor must be DRY. He can also safely grasp the body of the victim if his hands are protected by several thicknesses of dry cloth, such as a coat or overcoat. Where possible, only one hand should be used.

Often, a line may be short-circuited by throwing an iron chain, crowbar, piece of pipe, or some other metal object across the two conductors of the circuit. This will cause the circuit-breaker to open the circuit, or will blow the fuses protecting the electrical system. Great care should be taken to obtain proper insulation from the metal parts when executing this work. The hands should leave the metal object before it touches the wires. In case the victim is in contact with a trolley wire, for example, a metal pipe or a length of wire should be placed firmly in contact with the track rail, and then thrown across the trolley wire, connecting it to the rail. Great caution should be observed in performing this operation. The pipe or wire should leave the hands before it touches any part of the conductor of the circuit. Even then, the hands should be insulated with rubber gloves, or thick folds of cloth. Opening the circuit by means of a nearby circuit-breaker or switch is the surest way of safely releasing the victim. There should be no reckless haste in attempting to release him, but the rescue work should be done quickly and intelligently.

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[1] The subject matter under this heading is an extract from a book on "Electrical Injuries" by Dr. C. A. Lauffer, Medical Director, Westinghouse Electric and Mfg. Co., published by John Wiley & Sons, New York.

TABLE OF POISONS, SYMPTOMS, AND ANTIDOTES

Poison	*Symptoms*	*Emetic*	*Antidotes*
Strong mineral acids	Immediate burning pain in mouth, throat, stomach and abdomen. Vomiting, purging, shock, suffocation, and exhaustion	None	Magnesia, soap and water, chalk and water
Caustic alkalis (ammonia, potash, soda, etc.)		“	Lemon juice or vinegar
Oxalic acid		“	Magnesia, chalk and water
Corrosive sublimate		“	Raw eggs beaten up, flour and water, milk
Chloride of zinc		“	Bicarbonate of soda followed by raw eggs
Chloride of antimony		“	Tea, coffee, tannic acid and water
Arsenic	Symptoms may not appear at once; they vary considerably. After a time, pain and dryness of throat, sickness, vomiting, loss of voice, cold sweat, shock and exhaustion	Zinc sulphate and water	Tincture of steel, and bicarbonate of soda and water, raw eggs and milk, oil and lime water
Tin		“	Carbonate of ammonia and water
Lead		“	Epsom salts and water
Copper		“	Raw eggs and milk
Phosphorus		“	Magnesia or chalk mixed in milk or gruel
Iodine		“	Starch and water gruel
Cantharides		“	Linseed tea gruel
Irritant gases	Headache and drowsiness	None	Fresh air, artificial respiration
Opium (laudanum, morphine)	Giddiness, headache, dimness of vision, contracted eye pupils, drowsiness and stupor	Mustard and water	Keep patient awake, hot coffee
Belladonna and henbane	Enlarged pupils, thirst, delirium	Zinc sulphate	Charcoal powder and water, hot coffee
Strychnine	Violent convulsions, lock-jaw, but mind quite clear	Stomach pump required	Plenty of olive oil to drink
Cyanide or prussic acid	Usually quick death by shock	Zinc sulphate	Brandy and water; dash cold water on face, head and chest

Carbolic acid	Intense burning pain from mouth to stomach, giddiness, breath smells of carbolic acid	Zinc sulphate or mustard and water	Magnesia mixed with olive oil, raw eggs and milk
Aconite	Numbness, tingling, burning and tightness felt in throat	Zinc sulphate	Brandy and water, rub limbs and spine with hot towels.
Silver nitrate	Immediate vomiting	None	Common salt and water or sea-water

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DO NOT REMOVE
OR
MUTILATE CARD